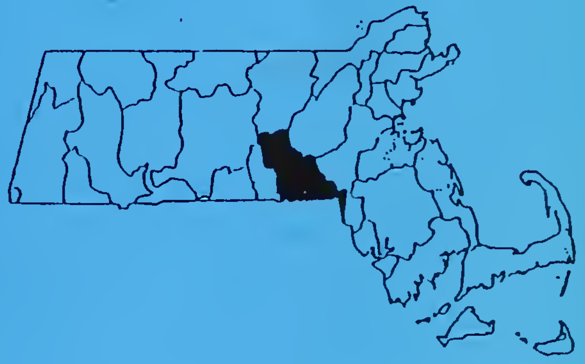
MASS. EA 12.2: B56/991/v.1

UMASS/AMHERST
312066 0270 8376 2

Volume I

Blackstone River Basin

Inventory and Analysis of Current and Projected Water Uses



January 1991

Prepared for the
Massachusetts Water Resources Commission

Massachusetts Executive Office of Environmental Affairs
Department of Environmental Management
Division of Resource Conservation
Office of Water Resources

William F. Weld, Governor ○ Susan F. Tierney, Secretary EOEA ○ Peter C. Webber, Commissioner DEM

912/366

BLACKSTONE RIVER BASIN
VOLUME I

Inventory and Analysis of Current and Projected Water Uses

prepared for the

Massachusetts Water Resources Commission
Executive Office of Environmental Affairs

Department of Environmental Management
Division of Resource Conservation
Bureau of Resource Protection
Office of Water Resources

Katherine Abbott
Deputy Commissioner

Richard H. Thibedeau
Director

January 1991

Publication No. 16,623-137-100-3-91-C.R.
Approved by Ric Murphy, State Purchasing Agent

EXECUTIVE SUMMARY

This report is an update of the Inventory and Analysis of Current and Projected Water Use in the Blackstone River Basin printed in May, 1985. As the first step in developing a comprehensive water resources management plan for the Blackstone River basin, it is intended to provide a basis for making sound water resource management decisions. The Office of Water Resources (OWR) has compiled data on existing water uses and water demand for communities in the study area, and has projected water needs through the year 2020. The following are summary points from the report:

* The base (1986-88) average day water demand (ADD) for public water supplies in the Blackstone River study area was approximately 42.04 million gallons per day (mgd). The ADD is projected to increase by 45 percent to 60.98 mgd by 2020 if concerted conservation efforts are not instituted. The increase is based on significant growth projected for commercial and industrial water use in several communities and population growth. The basin population is projected to reach 377,975 by 2020, an increase of 16 percent from 1986.

* The Blackstone River basin study area includes eighteen communities with land area in the basin. Sixteen of these communities use the Blackstone basin as a source for all or some of their public water supply.

* Blackstone basin communities are served totally, or in part, by 25 public water supply agencies. Neither Millville, nor Mendon, have a public water supply system, although a section of Mendon is served by the Milford Water Company.

* Of the 325,867 people in the Blackstone basin, 295,237 or 91 percent, are served by a public water supply system.

* Surface water sources supplied 27.30 mgd, or 64 percent, and ground water sources supplied 15.56 mgd, or 36 percent of the water used by public water supply systems in 1988. Only Worcester obtained all of its water supply from surface sources.

* If the maximum day demand for all communities had occurred on the same day, the total amount of water used by the basin's public water supply systems would have been 65.87 mgd.

* 26.44 mgd was withdrawn from the Blackstone River basin for water supply use in 1988, and 36.48 mgd was discharged into the Blackstone River basin as wastewater, resulting in a net inflow of 10.04 mgd.

* Worcester has the largest 1986 population of all communities in the study area, 157,770 people. This city accounts for 52 percent of the study area's population and approximately 60 percent (26.78) of the study area's 1988 water

demand. Worcester imports 12.97 mgd into the basin from the Nashua River basin, which accounts for 30 percent of the 1988 basin demand.

TABLE OF CONTENTS

PAGE

EXECUTIVE SUMMARY.................................... i

LIST OF TABLES....................................... iv

LIST OF FIGURES...................................... v

LIST OF APPENDICES................................... v

PREFACE.. vi

INTRODUCTION... 1

I. BLACKSTONE RIVER BASIN DESCRIPTION................ 2

II. STUDY AREA DESCRIPTION........................... 4

III. PUBLIC WATER SUPPLY SYSTEMS..................... 4

- A. 1988 Demand.................................... 4
- B. 1988 Sources of Supply......................... 5
- C. Contamination of Public Water Supplies... 9
- D. 1988 Type of Supply............................ 11
- E. 1988 Estimated Distribution of Water Use. 11
- F. Inflow - Outflow Analysis...................... 16

IV. DEMOGRAPHIC PROFILE.............................. 19

- A. Population and Population Trends......... 19
- B. Population Density............................ 19
- C. Seasonal Population........................... 21
- D. Service Population............................ 21
- E. Projected Service Area Expansion......... 21
- F. Population Projections........................ 22

V. PROJECTED WATER DEMAND........................... 28

- A. Introduction................................... 28
- B. Base Demand.................................... 28
- C. Gallons Per Capita Per Day.................... 29
- D. Base MDD and MDD\ADD Ratio................... 31
- E. Water Demand Projection Assumptions...... 31
- F. Water Demand Projection Methodology...... 33

APPENDICES... 37

LIST OF TABLES

PAGE

1. Blackstone River Basin Planning Format.................... ix
2. 1980 to 1988 Average Day Demands 6
3. 1980 to 1988 Maximum Day Demands 7
4. 1988 Source of Supply by Basin............................. 10
5. 1988 Type of Water Supply.................................. 12
6. 1988 Estimated Distribution of Water Use................... 14
7. 1988 Inflow - Outflow - Blackstone River Basin............. 17
8. 1940 to 1986 Population Trends 20
9. 1986 Federal Census Estimates, Land Area, and Density...... 24
10. 1988 Service Population 25
11. 1988 to 2020 Projected Service Population Expansion........ 26
12. 1980 to 2020 Population Projections........................ 27
13. 1980 to 1988 GPCD Changes 30
14. 1986 to 1988 Average Day Demand (ADD), Maximum Day Demand (MDD) and MDD to ADD Ratios.................................. 32
15. 1995 to 2020 Average Day Demand Projections................ 34
16. 1995 to 2020 Maximum Day Demand Projections................ 35
17. 2020 Water Demand Projections.............................. 36

LIST OF FIGURES

PAGE

1. Massachusetts River Basins for Water Resources Planning. viii
2. Blackstone River Basin and Study Area Map................ 3
3. Average and Maximum Day Demand Changes: 1980 to 1988..... 8
4. Estimation Distribution of Water Use..................... 15
5. Inflow - Outflow Analysis................................ 18
6. Population Trends and Projections (1940 to 2020)......... 23

LIST OF APPENDICES

PAGE

1. Blackstone River Basin Study Area Water Supply Agencies.. 37
2. General Water Demand Projection Methodology............ 42
3A. Process Used to Identify and Locate Public Water Supply Sources............................ 48
B. Map of Blackstone River Basin Water Supply Sources...... 50
C. Public Water Supply Source Sites and Locations.......... 51
4. Water Management Act.................................... 57
5A. Self-Supplied Residential Water Use..................... 59
B. Self-Supplied Non-Residential Water Use................. 61
6. Community Public Water Supply Facts and Maps........... 62

PREFACE

The Massachusetts Water Resources Commission (WRC) has the primary responsibility for determining state water resources policy and directing the water resources planning activities for the Executive Office of Environmental Affairs. The Office of Water Resources, in the Department of Environmental Management, provides technical staff support to the Commission and is responsible, through the Commission, for long-range water resources planning for the Commonwealth. The central element in the development of a statewide water resources management plan is the preparation of a management plan for each of the twenty-seven river basins of the Commonwealth. (See Figure 1). These plans are being developed pursuant to the Water Resources Planning Regulations (313 CMR 2.00) adopted by the Commission. The basin planning process includes local, regional, and state assessments of water needs and the availability of water resources.

The river basin planning process (See Table 1) consists of five steps:

1. Development of an inventory of the basin's water uses.
2. Analysis of data and identification of future water needs in the basin.
3. Development and analysis of alternatives to meet these projected needs.
4. Preparation of a basin-specific water resources management plan for the approval of the Water Resources Commission.
5. Adoption of the plan by the Water Resources Commission.

This first volume represents the inventory step of the planning process. It includes the collection of existing data on the river basin's current and projected water demand, active water supply sources, and short- and long-term demographic profiles for communities in the study area.

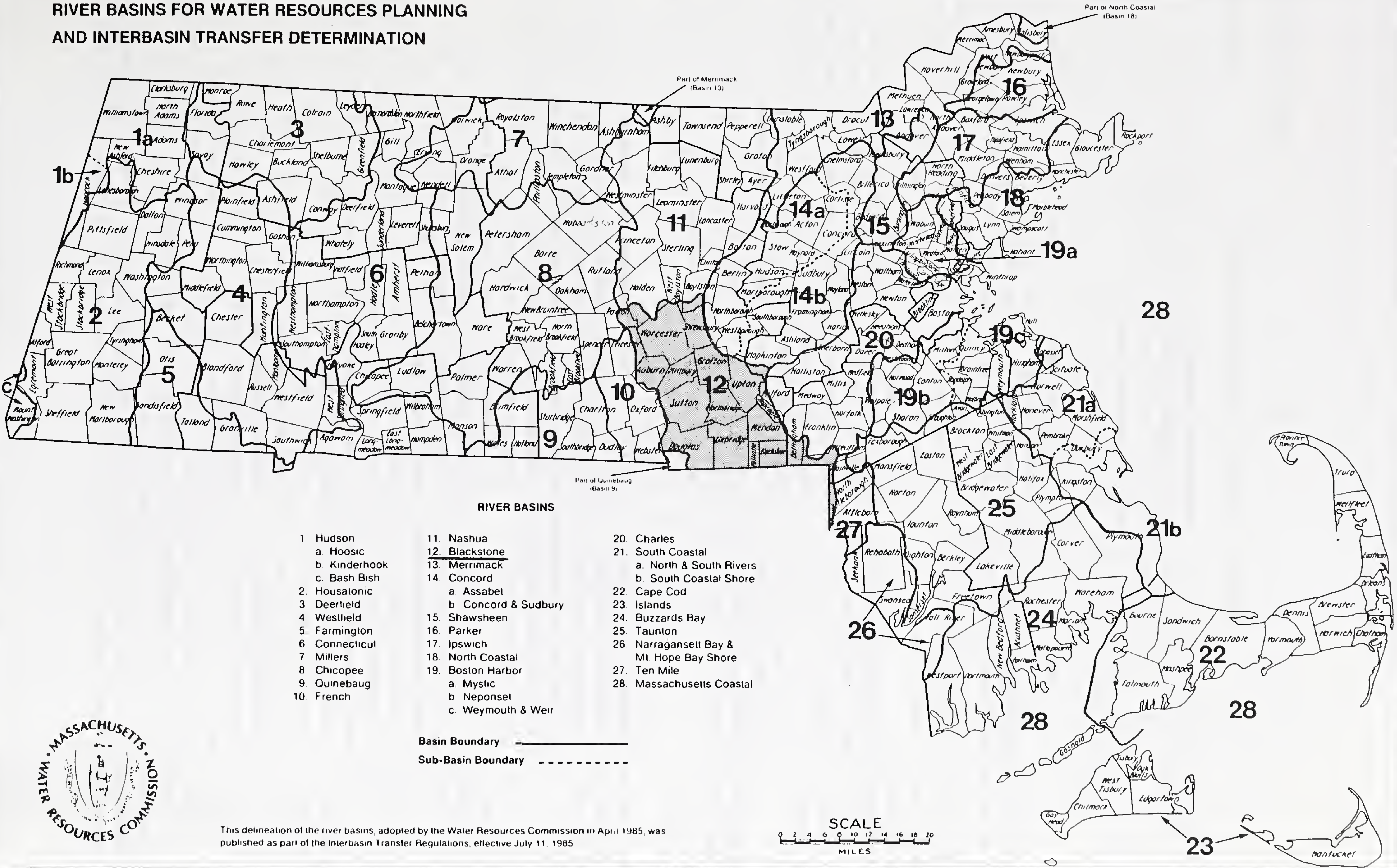
The second volume will use the inventory data and water demand projections in a computer or other analytical model to determine subbasin yield in drought conditions. The analysis includes OWR-recommended guidelines for a minimum streamflow threshold for the river. Minimum streamflow protects a variety of river uses, including wildlife, fin and shellfish, and considers the needs of irrigation, hydropower, recreation and wetlands, as well as municipal and industrial water supply, and the dilution of effluent.

When the analysis has been completed, a basin water budget can be prepared to estimate the volume of water available under both average precipitation and drought conditions. The basin water budget will provide an estimate of the basin’s ability to meet projected water needs with available resources and any planned water supply developments.

Volume III, the Basin Plan, focuses on developing water conservation and supply alternatives, primarily for those communities in stressed subbasins. The conclusions and recommendations approved by the WRC will be published as the Basin Plan.

Figure 1

RIVER BASINS FOR WATER RESOURCES PLANNING AND INTERBASIN TRANSFER DETERMINATION



RIVER BASINS

1. Hudson
   - a. Hoosic
   - b. Kinderhook
   - c. Bash Bish
2. Housatonic
3. Deerfield
4. Westfield
5. Farmington
6. Connecticut
7. Millers
8. Chicopee
9. Quinebaug
10. French
11. Nashua
12. Blackstone
13. Merrimack
14. Concord
   - a. Assabet
   - b. Concord & Sudbury
15. Shawsheen
16. Parker
17. Ipswich
18. North Coastal
19. Boston Harbor
   - a. Mystic
   - b. Neponset
   - c. Weymouth & Weir
20. Charles
21. South Coastal
   - a. North & South Rivers
   - b. South Coastal Shore
22. Cape Cod
23. Islands
24. Buzzards Bay
25. Taunton
26. Narragansett Bay & Mt. Hope Bay Shore
27. Ten Mile
28. Massachusetts Coastal

Basin Boundary ————

Sub-Basin Boundary - - - - - - - - -

This delineation of the river basins, adopted by the Water Resources Commission in April 1985, was published as part of the Interbasin Transfer Regulations, effective July 11, 1985

Executive Office of Environmental Affairs • Water Resources Commission

Prepared by the Department of Environmental Management • Division of Water Resources

Table 1

MASSACHUSETTS DEPARTMENT OF ENVIRONMENTAL MANAGEMENT

OFFICE OF WATER RESOURCES
RIVER BASIN PLANNING PROGRAM

RIVER BASIN PLANNING FORMAT

STEP 1	**STEP 2**	**STEP 3**	**STEP 4**	**STEP 5**
DEVELOP INVENTORY OF BASIN SUPPLY AND DEMAND	ANALYZE BASIN INVENTORY AND IDENTIFY FUTURE WATER NEEDS	DEVELOP AND ANALYZE ALTERNATIVES TO MEET PROJECTED NEEDS	PREPARE WATER RESOURCES MANAGEMENT PLAN	ADOPT PLAN
(a) Demographic profile of each Community from Federal, State, Regional and Community Studies.	(a) 1995-2020 population changes of each community.	(a) Local alternatives to meet projected community water needs (conservation, infrastructure storage, interconnections with contiguous communities).	(a) Selection by WRPTF for Step 3(d) communities of the best mix of new local and regional alternatives (Step 3 a & b) to meet deficits.	(a) WRC review of final draft plan.
(b) Historical and existing water demand of each community.	(b) 1995-2020 projected water demand of each community.	(b) Preliminary regional alternatives (MWRA, diversions, new regional reservoirs, interconnection).	(b) Selection of alternative(s) for all communities and basins.	(b) WRC vote on plan's adoption or adoption with modification.
(c) Existing and proposed water supply sources and systems via questionnaire replies.	(c) Existing and proposed water supply sources and systems as presented in questionnaire replies.	(c) Analysis and comparison of the relevant economic, environmental and institutional impacts of the alternatives and assessment of their ability to meet future needs.	(c) Preparation of draft plan.	
(d) Water resources management structure and organization via questionnaire replies.	(d) Conservation measures reported in questionnaire replies compared to the state conservation guidelines i.e. retrofit, leak detection, system rehabilitation, public education, ground water protection.	(d) Identification of deficient communities using local alternatives and not using regional alternatives per Step 3(b)	(d) Review and comment by local, regional, and state agencies and the Water Resources Commission on draft basin plan.	
(e) Water requirements for recreation, fish, wildlife, agriculture, hydropower and dilution.	(e) Task Force analysis of minimum streamflow thresholds.		(e) Preparation of final plan based on review comment.	
(f) Outline by DEP of basin water quality.	(f) Relationship between available water resources, projected demand and minimum streamflow thresholds.			
(g) Unregulated historical streamflow data.	(g) Community and basin deficits.			

<--------------- CONTINUOUS INTERACTION WITH LOCAL, REGIONAL AND STATE AGENCIES --------------->

The adopted plan is one of the factors included in decision making under the Interbasin Transfer Act, Water Resources Management Act and MWRA Contracts, as outlined in 313 CMR 2.00, Water Resources Management Planning Regulations.

INTRODUCTION

Purpose

The Blackstone River, its tributaries, and the lakes, ponds, and subsurface aquifers in the basin provide a valuable resource for the basin communities and for the Commonwealth. The information in this volume provides a basis for sound water resource management in the Blackstone River Basin study area. This report summarizes the water demand and water use data for communities with central water supply systems in the study area and includes 1986-1988 water use demand data for these communities, 1988 information on the sources of central water supply systems, 1986 population figures, 1995-2020 population forecasts, and 1995-2020 projected water demands.

Methods

The water use data was obtained from the superintendents of twenty-five water supply systems and from the Division of Water Supply, Department of Environmental Protection (DEP). The OWR requested water supply superintendents to update the 1982 Municipal Water Resource Management Plan - Phase II Questionnaire or to complete a new water supply questionnaire. Each superintendent reviewed, updated, and verified the accuracy of the data. To obtain more detailed information on water use and supply, OWR staff interviewed each water agency superintendent, either in person or by telephone.

Population projections were obtained from the Massachusetts Institute of Social and Economic Research (MISER), the Metropolitan Area Planning Council (MAPC), and community planning departments. The base population year of 1986 was chosen because it was the most recent year in which federal census information was available.

Base water demand for a community was calculated by averaging its 1986-1988 average day demand. Demand data is available for 1980 through 1988 (See Tables 2 and 3); however, changes in population growth and water conservation in most communities caused earlier water use patterns to change. Therefore, the 1986-1988 period was chosen as most representative of current water use (See Section IV for a full discussion).

Water demand projections for 1995-2020 were developed using the methodology outlined in Appendix 2. This methodology is based on assumptions concerning population growth and water use in the study area during the next thirty-five years. The water demand projections are used in the analysis of basin water supply and demand carried out in Volume II. Individual water supply and conservation alternatives for each town will be detailed in the basin plan (Volume III).

In addition, the basin plan will include updated information on new sources of supply that may have come on line, more recent population figures, and other information affecting demand that has become available since the publication of Volume I. Water demand projections may require periodic revision as new data becomes available, as the projection methodology improves, or as unforeseen social and economic changes occur. Therefore, the projections in Volume I may differ from those that appear in the final basin plan.

I. BLACKSTONE RIVER BASIN DESCRIPTION

The Blackstone River basin is located in south central Massachusetts (See Figure 2). The basin is bounded on the east by the Charles River basin and the Ten Mile River basin; on the north by the Nashua and Concord River basins; and on the west by the French and Chicopee River basins. Its headwaters rise in towns adjacent to the City of Worcester and drain southeasterly through Rhode Island to Narragansett Bay.

The Mill and Middle Rivers become the Blackstone River in the southern part of the City of Worcester. The Blackstone is 41 miles long and flows southeasterly for about 30 miles to the Massachusetts-Rhode Island border. The river drops from elevation 430 feet in Worcester to elevation 150 feet at the state line. This drop results in an average hydraulic gradient of 9 feet per second at the Woonsocket gage in Rhode Island.

The Blackstone River basin drains 493 square miles, 335 square miles of which are in Massachusetts. The river basin consists of 15 subbasins which will be described in more detail in Volumes II and III. The basin provides water to 295,237 people through public water supply systems and to an estimated 29,600 on private water supply. The basin supports a significant industrial sector, and provides important fisheries resources and recreational activities.

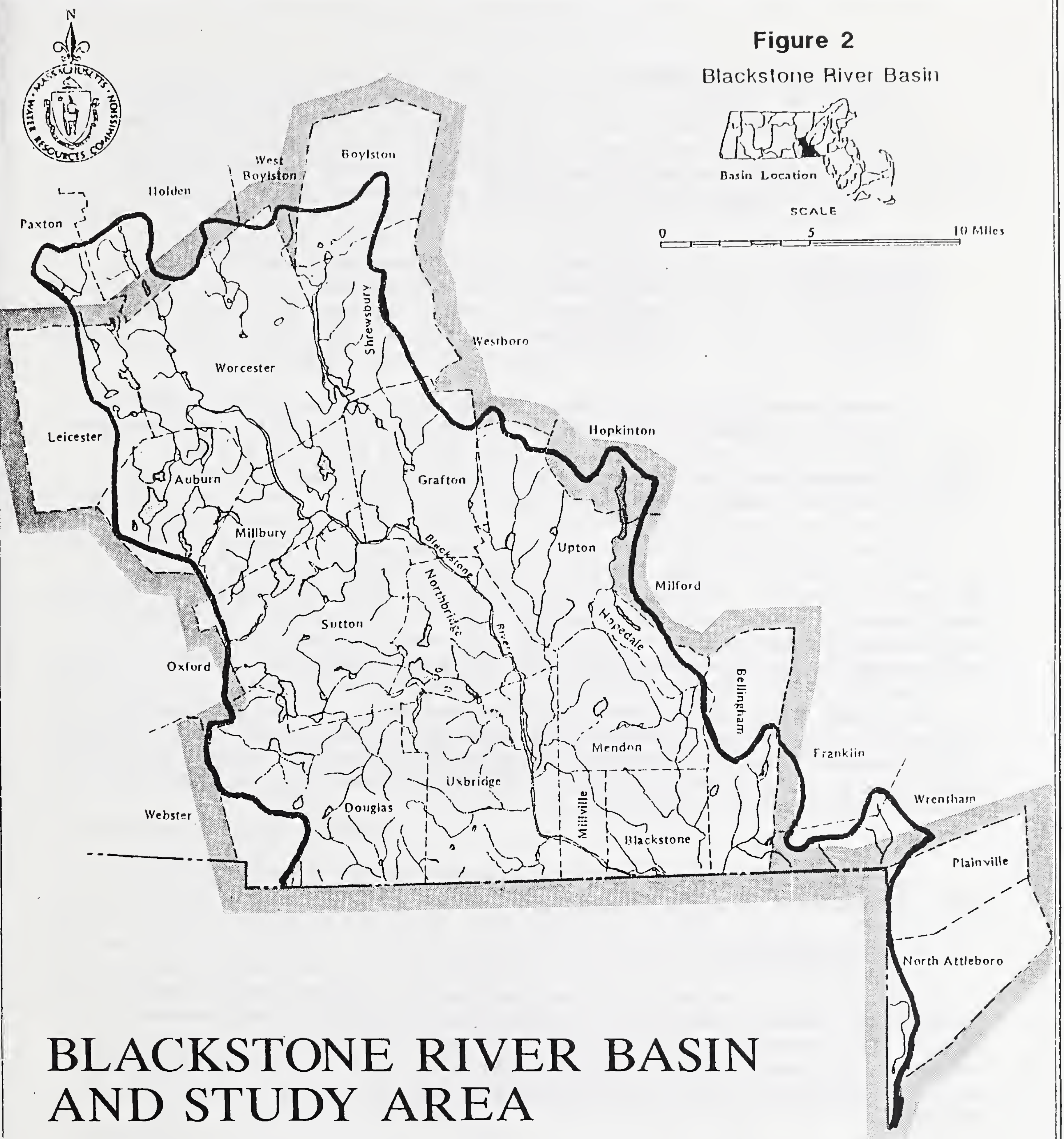


Figure 2

Blackstone River Basin

BLACKSTONE RIVER BASIN AND STUDY AREA

River basin boundary

▨ Study area communities boundary

DEM/Division of Water Resources

II. STUDY AREA DESCRIPTION

The Blackstone River basin study area (referred to as the study area) includes eighteen communities with either a majority of their land area in the basin or public water supply sources in the basin. These communities, as shown in Figure 2, are:

Auburn
Bellingham
Blackstone
Boylston
Douglas
Grafton
Hopedale
Leicester
Mendon
Millbury
Millville
Northbridge
North Attleboro
Shrewsbury
Sutton
Upton
Uxbridge
Worcester

Sixteen communities use the Blackstone basin as a source for all or some of their public water supply. The portion of Mendon with public water supply is serviced by the Milford Water Company whose sources are in the Charles River basin. Millville has no public water supply system.

Holden, Hopkinton, Paxton, and Wrentham have small sections of their land area, but no public water supply source(s), in the Blackstone basin. These four communities have one or more non-domestic, self-supplied source in the Blackstone and are included in this report under existing and projected self-supplied water demand in the Blackstone basin.

Several other towns have small sections of land within the basin but currently obtain little, if any, water supply from the Blackstone. Franklin, Milford, Oxford, Plainville, Webster, West Boylston, and Westborough fall into this category and are not included in the study area.

III. PUBLIC WATER SUPPLY SYSTEMS

A. 1988 Demand

In 1988, 91 percent of the population, or 295,237 people living in the 18 study area communities obtained their water supply from public water supply systems. The other nine percent of the population obtained their water from on-site residential or institutional wells. The 1988 average day demand for the study area was 42.86 mgd.

Sixteen study area communities are served totally or in part by a public water supply system. These communities are served by 25 public water supply agencies, consisting of 12 fire and water districts, 4 independently-owned water supply utilities and 9 city or town water departments. The towns of Millville and Mendon do not have a public water supply system, although a small section of Mendon is served by the Milford Water Company in Milford. Neither community has plans to install a central system.

The City of Worcester is the largest user of water in the basin, with a 1988 average day demand of 26.78 mgd, or 62 percent of the total average day demand in the study area.

Several communities experienced periodic water shortages due to drought or reduced groundwater levels. In 1988, under DEP approved water supply emergency declarations, Blackstone and Hopedale declared water supply emergencies and Bellingham instituted voluntary restrictions.

The public water supply agencies serving the Blackstone study area are listed in Appendix 1 of this report.

Water use in the study area has increased by ten percent from 1980 to 1988. The average and maximum day demands for each study area community from 1980 to 1988 are presented in Tables 2 and 3 and Figure 3.

Sources of Data

Water demand figures were obtained from the annual "Water Supply Statistics Report" submitted by each water supply agency to the Division of Water Supply in the Department of Environmental Protection (DEP). The average day demand for each year was calculated by dividing the annual water consumption by 365 days (366 in 1980 and 1984, leap years) to produce a base figure in units of million gallons per day.

B. 1988 Source of Supply

The study area's total average day demand was 42.86 mgd in 1988. Of this, about 38 percent, or 16.42 came from sources outside the Blackstone basin. Worcester accounts for 30 percent of the water imported. The volumes and percentages of water provided by other basins to Blackstone basin public water supply systems are shown below.

Basin	Volume of ADD (mgd) supplied	Percent
Charles	0.61	2
Nashua	12.97	30
Concord	0.17	<1
French	0.36	1
Ten Mile	2.31	5
Total	16.42	38%

TABLE 2
1980 to 1988 AVERAGE DAY DEMAND (mgd)
BLACKSTONE RIVER BASIN STUDY AREA

COMMUNITY	1980	1981	1982	1983	1984	1985	1986	1987	1988
Auburn									
Auburn W.D.	1.02	1.04	1.07	1.04	1.09	1.16	1.24	1.24	1.24
Woodland W.D.	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Elmhill W.D.	0.06	0.07	0.06	0.08	0.06	0.06	0.06	0.07	0.07
Bellingham W.D.	1.03	1.08	1.16	1.13	1.15	1.26	1.27	1.35	1.48
Blackstone W.D.	0.37	0.45	0.42	0.43	0.45	0.46	0.51	0.56	0.60
Boylston									
Boylston W.D.	0.15	0.23	0.19	0.17	0.17	0.20	0.20	0.21	0.25
Morningdale W.D.	0.15	0.17	0.16	0.19	0.15	0.19	0.21	0.23	0.21
Douglas W.D.	0.18	0.22	0.19	0.21	0.19	0.21	0.21	0.24	0.24
Grafton									
Grafton W.D.	0.64	0.57	0.56	0.62	0.56	0.88	0.66	0.73	0.76
S.Grafton W.D.	0.18	ND	ND	ND	0.19	0.19	0.20	0.17	0.18
Hopedale W.D.	0.48	0.46	0.54	0.62	0.57	0.56	0.60	0.43	0.47
Leicester									
Leicester W.S.D.	0.18	0.18	ND	0.19	0.20	0.19	0.19	0.20	0.20
CV & R W.D.	0.30	0.32	0.27	0.24	0.27	0.25	0.24	0.27	0.26
Hillcrest W.D.	0.15	0.12	0.14	ND	0.06	0.06	0.06	0.07	0.07
Mendon	NO CENTRAL SUPPLY								
Millbury									
Mass. Amer. W.C.	1.16	0.96	0.90	0.99	1.07	0.99	1.15	1.09	1.67
Maple Hillside	0.02	0.02	0.02	0.02	0.02	*	*	*	*
Oakwood Heights	0.01	0.01	0.01	0.01	*	*	*	*	*
Millville	NO CENTRAL SUPPLY								
North Attleboro									
N. Attleboro W.D.	2.55	2.43	2.60	2.44	2.30	2.07	2.06	2.51	2.84
King's Grant W.C.	0.04	ND	ND	ND	0.04	0.04	0.04	0.05	0.07
Northbridge									
Northbridge W.D.	0.40	0.37	0.44	0.42	0.43	0.40	0.42	0.55	0.36
Whittinsville W.C.	0.73	0.80	0.69	0.66	0.64	0.62	0.58	0.59	0.76
Shrewsbury W.D.	2.55	2.90	2.72	2.48	2.70	2.79	3.13	3.20	3.19
Sutton									
Wilkinsonville W.D.	0.10	0.12	ND	0.07	ND	0.08	0.10	0.08	0.08
Manchaug W.D.	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Upton W.D.	0.23	ND	ND	ND	0.26	0.28	0.34	0.27	0.27
Uxbridge W.D.	0.67	0.71	0.70	0.69	0.54	0.59	0.69	0.67	0.75
Worcester W.D.	25.67	24.84	21.34	22.82	25.32	25.50	26.39	26.17	26.78
TOTALS	39.07	38.13	34.24	35.58	38.49	39.09	40.61	41.01	42.86

ND: No Data Available

* Purchased by Ma. Am. Water Co.

TABLE 3
1980 to 1988 MAXIMUM DAY DEMAND (mgd)
BLACKSTONE RIVER BASIN STUDY AREA

COMMUNITY	1980	1981	1982	1983	1984	1985	1986	1987	1988
Auburn									
Auburn W.D.	1.79	2.04	1.64	1.81	1.69	1.48	1.83	2.20	2.25
Woodland W.D.	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Elmhill W.D.	0.09	0.10	0.09	0.12	0.09	0.09	0.09	0.10	0.10
Bellingham W.D.	2.23	1.95	2.46	2.04	1.84	2.22	2.05	2.22	2.23
Blackstone W.D.	0.63	0.90	0.73	0.70	0.93	0.94	0.89	1.67	1.10
Boylston									
Boylston W.D.	0.23	0.34	0.29	0.26	0.25	0.30	0.28	0.29	0.38
Morningdale W.D.	0.23	0.26	0.24	0.29	0.23	0.29	0.32	0.35	0.32
Douglas W.D.	0.46	0.49	0.33	0.43	0.32	0.39	0.39	0.65	0.33
Grafton									
Grafton W.D.	1.02	0.94	1.19	1.02	1.18	1.74	1.46	1.48	1.35
S.Grafton W.D.	ND	ND	ND	ND	0.29	0.29	0.30	0.26	0.27
Hopedale W.D.	0.83	0.79	0.93	1.06	0.98	0.96	1.03	0.86	0.60
Leicester									
Leicester W.S.D.	0.29	0.24	ND	0.25	0.26	0.30	0.27	0.27	0.27
CV & R W.D.	0.55	0.48	0.48	0.64	0.56	0.40	0.44	0.43	0.49
Hillcrest W.D.	0.18	0.18	0.14	ND	0.09	0.09	0.09	0.11	0.10
Mendon			NO CENTRAL SUPPLY						
Millbury									
Mass. Amer. W.C.	1.62	1.65	1.32	1.49	1.67	1.97	2.13	1.63	2.85
Maple Hillside	0.03	0.03	0.03	0.03	*0.03	*	*	*	*
Oakwood Heights	0.02	0.02	0.02	*0.02	*	*	*	*	*
Millville			NO CENTRAL SUPPLY						
North Attleboro									
N. Attleboro W.D.	4.64	4.10	4.10	4.32	3.43	3.81	3.98	5.15	5.41
King's Grant W.C.	ND	ND	ND	ND	0.06	0.06	0.06	0.08	0.13
Northbridge									
Northbridge W.D.	1.65	1.68	1.70	1.70	1.42	2.01	1.61	1.59	1.89
Whittinsville W.C.	0.60	0.56	0.66	0.63	0.65	0.60	0.63	0.83	0.54
Shrewsbury W.D.	4.44	4.97	4.72	4.64	4.44	4.79	5.07	6.13	6.10
Sutton									
Wilkinsonville W.D.	0.18	0.20	ND	0.10	ND	ND	0.13	0.14	0.14
Manchaug W.D.	0.03	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Upton W.D.	0.38	ND	ND	ND	1.11	1.15	0.51	0.41	0.50
Uxbridge W.D.	0.97	0.90	0.92	0.93	0.72	0.93	0.93	1.11	1.39
Worcester W.D.	34.44	32.78	32.53	35.05	34.15	34.97	36.63	37.61	39.92
TOTALS	57.58	55.52	54.62	57.61	56.46	59.88	61.22	65.67	68.76

ND: No Data Available

* Purchased by Ma. Am. Water Co.

AVERAGE AND MAXIMUM DAY DEMAND CHANGES

1980 TO 1988

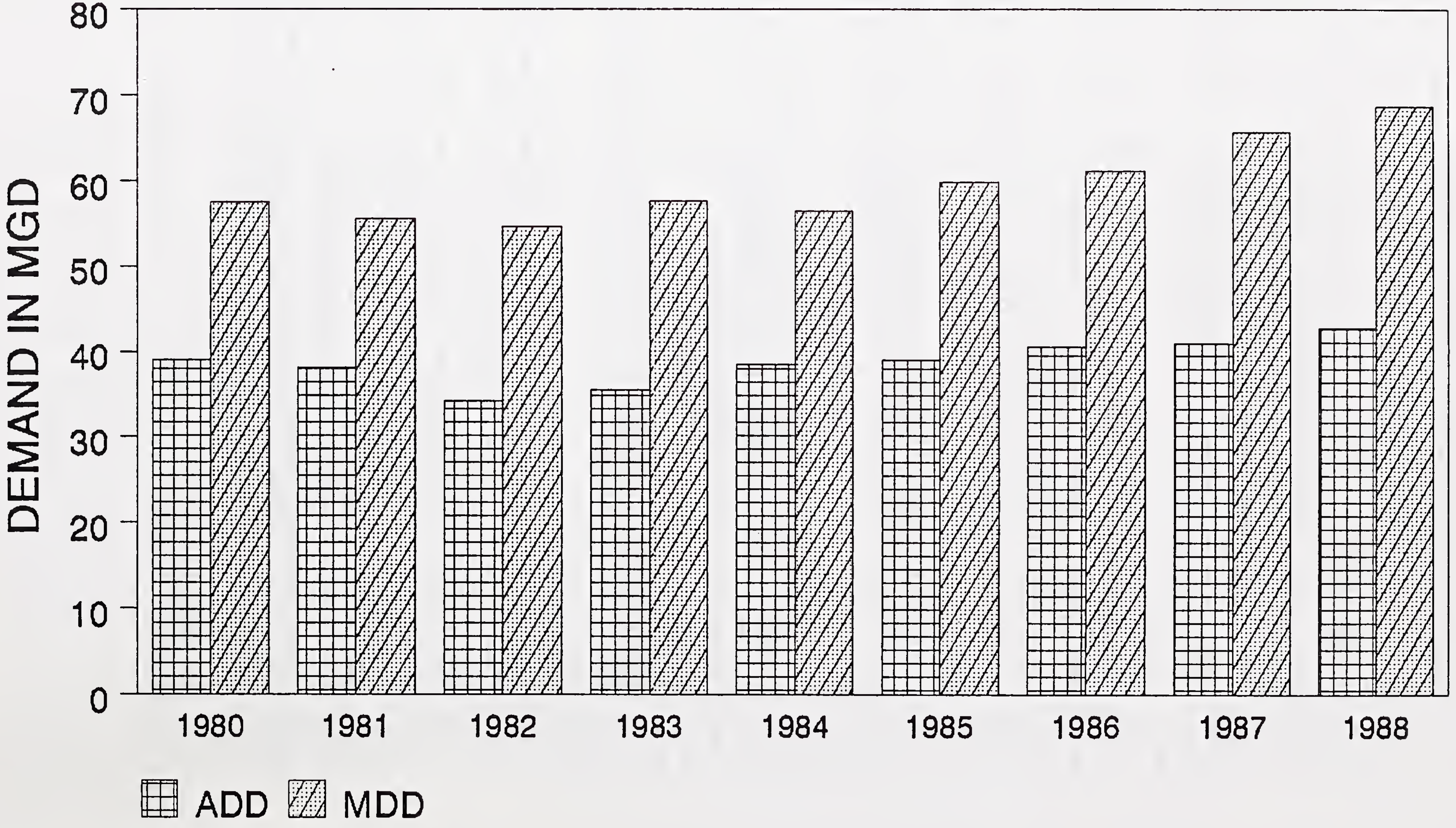


Figure 3

Ten of the sixteen study area communities which have public water supply systems obtain all of their water from sources located in the Blackstone River basin. The remaining six communities obtain water from the Blackstone and one other river basin.

Table 4 lists the portion of each community's average day demand (in mgd) obtained from the Blackstone and other river basins in 1988. Public water supply sources and their locations are presented in Appendix 3. Historic water demand data, projected water demands, and location of sources for each community are presented in Appendix 6.

C. Contamination of Public Water Supplies

Since the early 1970's, four communities in the study area have lost a public water supply well due to contamination (see listing below). A total of 6.79 mgd has been lost at some time to contamination, but 5.68 mgd has been or will soon be returned to use through treatment. Leicester's contaminated well is in the study area but is not located in the Blackstone River basin.

Many towns drawing water from the Blackstone basin region have problems with high levels of iron and manganese in ground water. Although the metals are non-toxic, they are aesthetically displeasing and in high concentrations stain various materials. Bellingham treats several wells to remove the metals.

Contaminated Sources in the Blackstone River basin

Town	Name	Year & Cause	Yield	Present Status
Auburn	Well #2	1972(sodium)	0.25	Permanently closed
Leicester	Hillcrest Country Club	1976(gasoline)	0.86	Permanently closed
Shrewsbury	Home Farm #6	1987(TCE)	2.88	Interim treatment limits use to 1.8 mgd. Building treatment plant.
Worcester	Coal Mine Brook	1977(coliform)	2.80	Expected to go on-line June 1990 with treatment

Sources of Data

Water supply officials in each community filled out a Municipal Water Resources Management Plan - Phase II questionnaire in 1982. This questionnaire was updated to 1986 by the municipalities and confirmed through personal interviews with water superintendents in 1989. The Division of Water Supply, DEP, Statistics Sheet, Section 2 for 1988, provided pumpage data for each water supply source.

Information on contaminated sources was obtained from the

TABLE 4
1988 SOURCE OF SUPPLY BY BASIN
BLACKSTONE RIVER BASIN STUDY AREA

COMMUNITY/ AGENCY	BLACKSTONE	CHARLES	NASHUA	CONCORD	FRENCH	TEN MILE	1988 ADD
AUBURN							
Auburn Water Dist.	1.24						1.24
Woodland Water Dist.	0.03						0.03
Elmhill Water Dist.	0.07						0.07
BELLINGHAM							
Bellingham W. Dept.	1.01	0.47					1.48
BLACKSTONE							
Blackstone W. Dept.	0.60						0.60
BOYLSTON							
Boylston W. Dist.	0.25						0.25
Morningdale W. Dist.	0.21						0.21
DOUGLAS							
Douglas W. Dept.	0.24						0.24
GRAFTON							
Grafton W. Dist.	0.76						0.76
So. Grafton W. Dist.	0.18						0.18
HOPEDALE							
Hopedale W. Dept.	0.33	0.14					0.47
LEICESTER							
Leicester W.S. Dist.	0.17				0.03		0.20
Cherry Vall. W. Dist.					0.26		0.26
Hillcrest W. Dist.					0.07		0.07
MENDON			NO CENTRAL SUPPLY				
MILLBURY							
Millbury Ma.Am.W.Co.	1.67						1.67
MILLVILLE			NO CENTRAL SUPPLY				
NORTH ATTLEBORO							
No.Attleboro W.Div	0.53					2.31	2.84
King's Grant W. Co.	0.07						0.07
NORTHBRIDGE							
Northbridge W.Co.	0.36						0.36
Whittinsville W.Co.	0.76						0.76
SHREWSBURY							
Shrewsbury W.Dept.	3.02			0.17			3.19
SUTTON							
Wilkinsonville WD	0.08						0.08
Manchaug W.D.	0.03						0.03
UPTON							
Upton Water Dept.	0.27						0.27
UXBRIDGE							
Uxbridge Water Dept	0.75						0.75
WORCESTER							
Worcester Water Dept	13.81		12.97				26.78
TOTAL (mgd)	26.44	0.61	12.97	0.17	0.36	2.31	42.86
PERCENT	62%	2%	30%	<1%	1%	5%	100%

1986 report, Contamination in Municipal Water Supplies by the Special Legislative Commission on Water Supply, and from interviews with water superintendents.

D. 1988 Type of Supply

In 1988, surface water sources supplied 27.30 mgd or 64 percent of the water used by public water supply systems in the study area. Only Worcester obtained all of its water supply from surface water sources.

Four communities, Auburn, Hopedale, Leicester, and Millbury, obtained their water supplies from both surface and ground water sources in 1988.

Ground water sources supplied 15.56 mgd, or 36 percent, of water used by public water supply systems in 1988. Eleven study area communities obtained 100 percent of its water supply from ground water sources.

The towns of Mendon and Millville currently have no public water supply systems. Millville obtains all of its water from private, on-site ground water sources. Mendon obtains most of its water supply from on-site ground water, and a small section of town is served by the Milford Water Company which has both surface and ground water sources.

Table 5 lists the volumes and percentages of the 1988 average day demands from surface and ground water sources of the study area communities. The figures represent each community's total 1988 water use from sources located in the Blackstone and other basins.

Sources of Data

The 1988 surface and ground water use for each water supply system was determined from the DEP, Division of Water Supply, Water Supply Statistics Sheets, Section 2, and interviews with water supply officials.

E. Estimated Distribution of Water Use 1988

Community water superintendents were asked to estimate various catergories of water use. Some communities are well metered and can give an accurate account of the water consumed in each category. Other community water system supervisors can make a good estimate of the water used in each category. However, some water systems were not able to break down water use by category. The numbers quoted below, therefore, should be regarded as approximations only.

TABLE 5
1988 TYPE OF WATER SUPPLY (mgd)
BLACKSTONE RIVER BASIN STUDY AREA

COMMUNITY/ AGENCY	1988 ADD	PERCENT SURFACE WATER USE	1988 ADD SURFACE WATER USE	PERCENT GROUND WATER USE	1988 ADD GROUND WATER USE
AUBURN					
Auburn Water Dist.	1.24	0	0.00	100	1.24
Woodland Water Dist	0.03	100	0.03	0	0.00
Elmhill Water Dist.	0.07	100	0.07	0	0.00
BELLINGHAM					
Bellingham W. Dept.	1.48	0	0.00	100	1.48
BLACKSTONE					
Blackstone W. Dept.	0.60	0	0.00	100	0.60
BOYLSTON					
Boylston W. Dist.	0.25	0	0.00	100	0.25
Morningdale W. Dist	0.21	0	0.00	100	0.21
DOUGLAS					
Douglas W. Dept.	0.24	0	0.00	100	0.24
GRAFTON					
Grafton Water Dist.	0.76	0	0.00	100	0.76
So. Grafton W. Dist	0.18	0	0.00	100	0.18
HOPEDALE					
Hopedale W. Dept.	0.47	30	0.14	70	0.33
LEICESTER					
Leicester W.S. Dist	0.20	0	0.00	100	0.20
Cherry Vall. W. Dis	0.26	100	0.26	0	0.00
Hillcrest W. Dist.	0.07	0	0.00	100	0.07
MENDON		NO CENTRAL SUPPLY			
MILLBURY					
Millbury Ma.Am.W.Co	1.67	1	0.02	99	1.65
MILLVILLE		NO CENTRAL SUPPLY			
NORTH ATTLEBORO					
No.Attleboro W.Div	2.84	0	0.00	100	2.84
King's Grant W. Co.	0.07	0	0.00	100	0.07
NORTHBRIDGE					
Northbridge W.Co.	0.36	0	0.00	100	0.36
Whittinsville W.Co.	0.76	0	0.00	100	0.76
SHREWSBURY					
Shrewsbury W.Dept.	3.19	0	0.00	100	3.19
SUTTON					
Wilkinsonville WD	0.08	0	0.00	100	0.08
Manchaug W.D.	0.03	0	0.00	100	0.03
UPTON					
Upton Water Dept.	0.27	0	0.00	100	0.27
UXBRIDGE					
Uxbridge Water Dept	0.75	0	0.00	100	0.75
WORCESTER					
Worcester Water Dep	26.78	100	26.78	0	0.00
TOTAL	42.86	64%	27.30	36%	15.56

Residential water use is the primary water use for most communities in the study area. Residential water use is defined as water used by individuals and families in houses, apartments, condominiums and mobile home parks. This category was estimated at 42 percent of the total volume furnished by public water supply systems in 1988. Worcester had the lowest percentage of residential water use with only 18 percent.

Commercial water use was reported to be 13 percent of total study area water use. The Auburn Water District reported the highest percentage of 29 percent in this category, followed by North Attleboro with 24 percent. Water in this category is defined as water used by businesses, other than industry.

Reported municipal water use was less than one percent of water used in the study area. Water in this category includes metered use to municipal buildings and water used for backwashing, street cleaning and other municipal services where that amount is known.

Industrial water use accounted for 17 percent of study area water use in 1988. The Town of Millbury reported the highest percentage of industrial use in the study area (51 percent), followed by Worcester (39 percent). Industrial use is defined as water used by industries for processing, cooling, and sanitation.

The "other" category accounted for only one percent of reported water use and was reported in Millbury, Northbridge, and Worcester. The "other" category includes water wholesaled to other water systems.

Agricultural water use was minimal (less than one percent) throughout the study area. The only agricultural use for public systems in the study area was reported in the Boylston Water District (10 percent).

Unaccounted-for water represented 27 percent of the study area's water demand. This is the most difficult category of water use to define, since its meaning is open to interpretation. As a result, different methods were used by local water supply agencies to calculate water use in this category. "Unaccounted-for" water may include water lost through leakage, water used to flush mains, water furnished to municipal buildings, and other unmetered uses. The accuracy of reporting varies from system to system.

The estimated 1988 water use distribution percentages for the study area are shown in Table 6 and Figure 4.

Sources of Data

The percentage distribution of water use for each water supply

TABLE 6
1988 ESTIMATED DISTRIBUTION OF WATER USE (IN PERCENT)
BLACKSTONE RIVER BASIN STUDY AREA

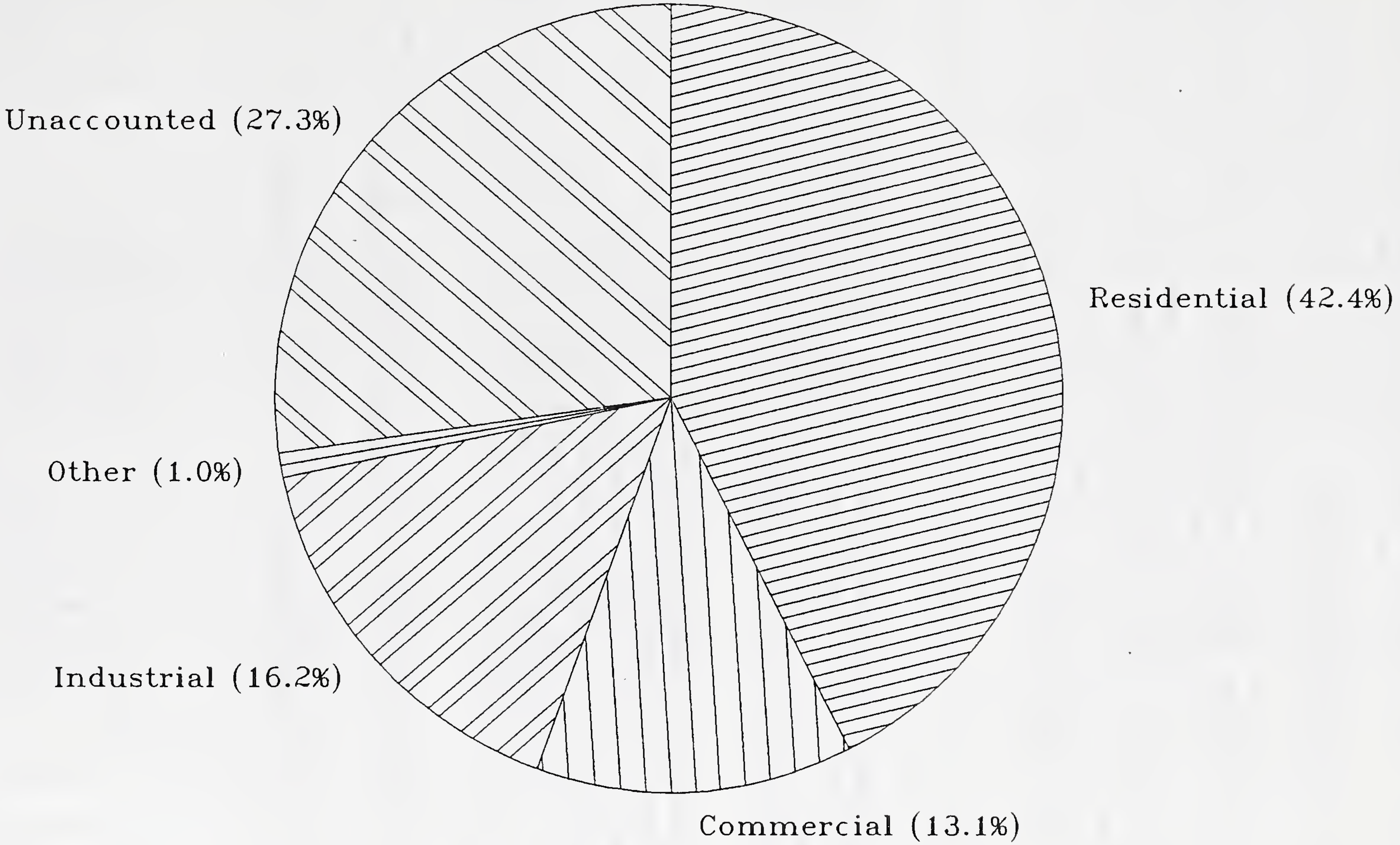
COMMUNITY/ AGENCY	Residential	Commercial	Industrial	Agricultural	Municipal	Other	Unaccounted
AUBURN							
Auburn Water Dist.	47	29	7	0	2	0	15
Woodland Water Dist.	95	0	0	0	0	0	5
Elmhill Water Dist.	85	5	5	0	0	0	5
BELLINGHAM							
Bellingham W. Dept.	57	7	0	0	0	0	36
BLACKSTONE							
Blackstone W. Dept.	75	6	0	0	1	0	18
BOYLSTON							
Boylston W. Dist.	49	7	0	10	1	0	33
Morningdale W. Dist.	40	1	1	0	1	0	57
DOUGLAS							
Douglas W. Dept.	80	0	0	0	0	0	20
GRAFTON							
Grafton Water Distric	51	5	27	0	3	0	14
So. Grafton W. Dist.	82	3	3	0	0	0	12
HOPEDALE							
Hopedale W. Dept.	70	15	0	0	0	0	15
LEICESTER							
Leicester W.S. Dist.	51	13	15	0	1	0	20
Cherry Vall. W. Dist.	59	8	1	0	1	0	31
Hillcrest W. Dist.	88	0	0	0	0	0	12
MENDON			NO CENTRAL SUPPLY				
MILLBURY							
Ma. Am. W. Co.	22	11	51	0	1	3	12
MILLVILLE			NO CENTRAL SUPPLY				
NORTH ATTLEBORO							
No.Attleboro W.Div	26	24	0	0	0	0	50
King's Grant W. Co.	95	0	0	0	0	0	5
NORTHBRIDGE							
Northbridge W.Co.	64	15	7	0	2	0	12
Whitinsville W.Co.	42	4	3	0	1	3	18
SHREWSBURY							
Shrewsbury W.Dept.	60	12	0	0	0	0	28
SUTTON							
Wilkinsonville WD	49	1	22	0	0	0	28
Manchaug W.D.	82	2	4	0	0	0	12
UPTON							
Upton Water Dept.	88	2	0	0	0	0	10
UXBRIDGE							
Uxbridge Water Dept	85	0	0	0	0	0	15
WORCESTER							
Worcester Water Dept	18	13	39	0	1	2	27
TOTAL	42%	13%	17%	<1%	<1%	1%	27%

NOTE: If unaccounted for water use was reported as less than 10% then we assigned 12% and reduced another category, except for Woodland, Elmhill, and King's Grant which was assigned 5%.

SOURCE: Department of Environmental Protection Statistic Sheet

ESTIMATED DISTRIBUTION OF WATER USE

BLACKSTONE RIVER BASIN STUDY AREA



system was obtained in discussions with water superintendents, and from the 1988 "Water Supply Statistics Report" submitted to the DEP by each public water supply system.

F. Inflow - Outflow Analysis

The Blackstone River basin supplies 62 percent of the water used by the public water supply systems in the study area communities. The amount of water withdrawn from the Blackstone River basin for water supply use is less than the amount of water discharged into the basin as wastewater. The result is a net inflow to the basin of 10.04 mgd, which is approximately 38 percent greater than the amount of water withdrawn from the basin. The other basins which import water from the Blackstone River basin are the Charles, Concord, and Ten Mile.

In total, 26.44 mgd was withdrawn from sources in the basin and 36.48 mgd was discharged into the basin.

The Nashua basin supplies 12.97 mgd (30 percent) of the water used by public systems in the study area. However, only one percent of this water is returned to the Nashua basin, making the Nashua a net exporter of water to the Blackstone basin.

The Ten Mile and Charles basins supply 2.31 and 0.61 mgd (5 and 2 percent) respectively, of the water used by public systems in the study area. Six percent or 2.73 mgd, of the study area’s total wastewater is discharged to the Ten Mile River basin and 2 percent, or 0.78 mgd is discharged to the Charles basin. Likewise, the Concord basin supplies 0.17 (less than one percent) and receives 2.34 mgd (5 percent) of wastewater discharge.

The French basin has an even exchange of water supplying 0.36 mgd and receiving 0.36 mgd as wastewater.

Table 7 and Figure 5 present the basin of origin and discharge for each community in the study area.

TABLE 7

1988 INFLOW - OUTFLOW ANALYSIS (mgd)

BLACKSTONE RIVER BASIN STUDY AREA

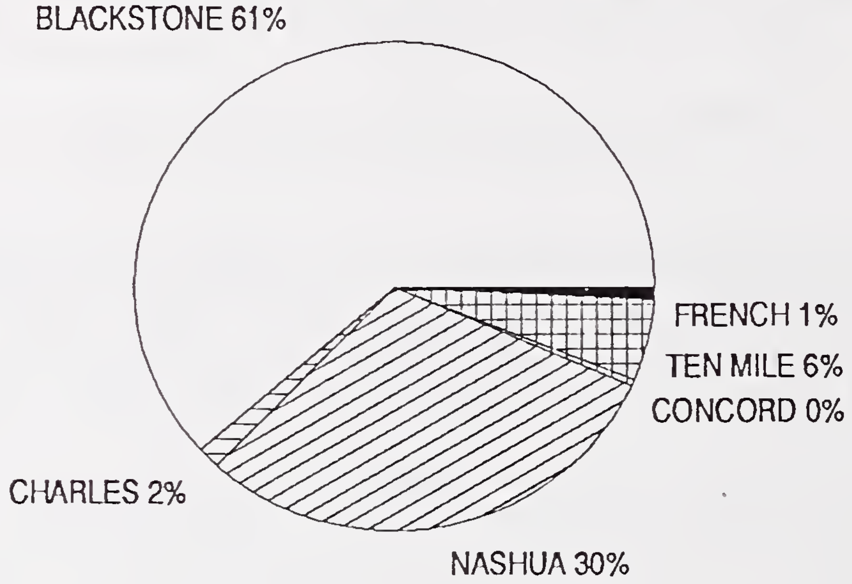
COMMUNITY/	---------- SOURCE OF WATER SUPPLY ----------						1988	----------- BASIN OF WASTEWATER DISCHARGE ---------						TOTAL
AGENCY	BLACKSTONE	CHARLES	NASHUA	CONCORD	FRENCH	TEN MILE	ADD	BLACKSTONE	CHARLES	NASHUA	CONCORD	FRENCH	TEN MILE	DISCHARGE
AUBURN														
Auburn Water Dist.	1.24						1.24	1.24						1.24
Woodland Water Dist.	0.03						0.03	0.03						0.03
Elmhill Water Dist.	0.07						0.07	0.07						0.07
BELLINGHAM														
Bellingham W. Dept.	1.01	0.47					1.48	0.74	0.74					1.48
BLACKSTONE														
Blackstone W. Dept.	0.60						0.60	0.60						0.60
BOYLSTON														
Boylston W. Dist.	0.25						0.25	0.08		0.17				0.25
Morningdale W. Dist.	0.21						0.21	0.21						0.21
DOUGLAS														
Douglas W. Dept.	0.24						0.24	0.24						0.24
GRAFTON														
So. Grafton W. Dist.	0.18						0.18	0.18						0.18
Grafton Water District	0.76						0.76	0.76						0.76
HOPEDALE														
Hopedale W. Dept.	0.33	0.14					0.47	0.43	0.04					0.47
LEICESTER														
Leicester W.S. Dist.	0.17				0.03		0.20	0.03				0.17		0.20
Cherry Vall. W. Dist.					0.26		0.26	0.14				0.12		0.26
Hillcrest W. Dist.					0.07		0.07					0.07		0.07
MENDON														
MILLBURY														
Millbury Ma.Am.W.Co.	1.67						1.67	1.67						1.67
MILLVILLE														
NORTHBRIDGE														
Northbridge W.Co.	0.36						0.36	0.36						0.36
Whittinsville W.Co.	0.76						0.76	0.76						0.76
NORTH ATTLEBORO														
No.Attleboro W.Div	0.53					2.31	2.84	0.11					2.73	2.84
King's Grant W. Co.	0.07						0.07	0.07						0.07
SHREWSBURY														
Shrewsbury W.Dept.	3.02			0.17			3.19	0.85			2.34			3.19
SUTTON														
Wilkinsonville WD	0.08						0.08	0.08						0.08
Manchaug W.D.	0.03						0.03	0.03						0.03
UPTON														
Upton Water Dept.	0.27						0.27	0.27						0.27
UXBRIDGE														
Uxbridge Water Dept	0.75						0.75	0.75						0.75
WORCESTER														
Worcester Water Dept	13.81		12.97				26.78	26.78						26.78
TOTAL (MGD)	26.44	0.61	12.97	0.17	0.36	2.31	42.86	36.48	0.78	0.17	2.34	0.36	2.73	42.86
PERCENT	62%	2%	30%	<1%	1%	5%	100%	85%	2%	1%	5%	1%	6%	100%

Figure 5

INFLOW OUTFLOW ANALYSIS

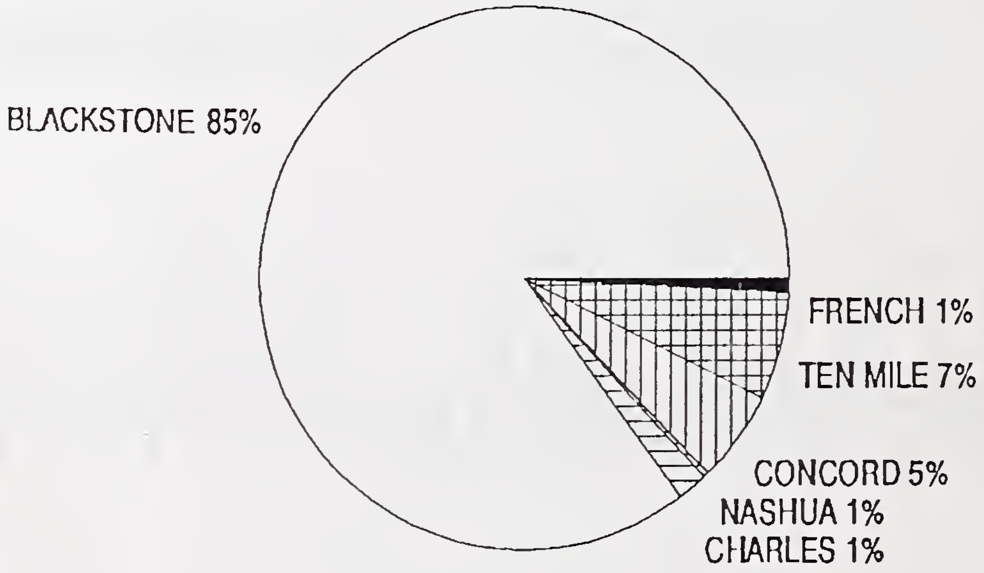
Source of Water Supply

Blackstone River Basin Study Area



Basin of Wastewater Discharge

Blackstone River Basin Study Area



IV. DEMOGRAPHIC PROFILE

A. Population and Population Trends

The 1980 federal census population for the study area was 320,042. The 1986 federal census estimate was 325,867, representing an increase of 5,825 (or nearly two percent) from the 1980 federal census.

Worcester is the study area's only city and the principal population center with a 1986 population of 157,770 or 48 percent of the study area's population.

Table 8 and Figure 6 show the study area's population changes from 1940 to 1986 and projections to 2020. In the decade of the 1940's, the basin communities experienced an eight percent increase in population. This growth trend slowed to three percent in the 1950's, climbed to five percent in the 1960's, and declined by two percent during the 1970's. Except for Auburn and Shrewsbury, the population in the study area increased during the 1980's. The basin population is projected to increase by 52,108, or 16 percent, from 1986 to 2020. Projections indicate that all communities will increase in population between five and 48 percent. Three communities, Bellingham, Douglas, and Millville, are projected to have an increase of over 40 percent. Worcester is expected to increase by 19,363 or 12 percent. A more complete discussion of the population projection methodology is found in Appendix 2.

Sources of Data

The 1980 federal census figures, "Numbers of Inhabitants Massachusetts - 1980 Census of Population" and the 1986 federal census estimate are prepared by the Bureau of the Census, U.S. Department of Commerce. The estimates were prepared using procedures that rely on measuring components of population change. They utilize statistics on births and deaths by residence to estimate natural increase, federal income tax returns to estimate net internal migration, and reported immigration statistics to estimate net migration. These figures include all persons indicating a particular city or town as their place of residence. College students were counted as being residents of the area in which they are living while attending college. Inmates of institutions, who ordinarily live there for a considerable period of time, were counted as residents of the community where the institution is located. In communities where the town census was used, the census was provided by the town.

B. Population Density

Worcester is the most densely-populated community in the study area with 4,095 persons per square mile, followed by North

TABLE 8
1940 to 1986 POPULATION TRENDS
BLACKSTONE RIVER BASIN STUDY AREA

	FEDERAL CENSUS					1986 FED CENSUS	CHANGE 1980 TO 1986	
COMMUNITY	1940	1950	1960	1970	1980	ESTIMATE	NUMBER	PERCENT
AUBURN	6,629	8,840	14,047	15,347	14,845	14,580	-265	-2%
BELLINGHAM	2,979	4,100	6,774	13,967	14,300	14,230	-70	0%
BLACKSTONE*	4,566	4,968	5,130	6,566	6,570	7,767	1197	18%
BOYLSTON	1,388	1,700	2,367	2,774	3,470	3,530	60	2%
DOUGLAS	2,617	2,624	2,559	2,947	3,730	4,590	860	23%
GRAFTON	7,457	8,281	10,627	11,659	11,238	11,840	602	5%
HOPEDALE*	3,113	3,479	3,987	4,292	3,905	5,500	1595	41%
LEICESTER	4,851	6,029	8,177	9,140	9,446	9,680	234	2%
MENDON	1,315	1,619	2,068	2,524	3,108	3,490	382	12%
MILLBURY	6,983	8,347	9,623	11,987	11,808	11,840	32	0%
MILLVILLE	1,722	1,692	1,567	1,754	1,693	2,010	317	19%
NO.ATTLEBORO	10,359	12,146	14,777	18,665	21,095	23,460	2365	11%
NORTHBRIDGE	10,242	10,476	10,800	11,795	12,246	12,440	194	2%
SHREWSBURY	7,586	10,594	16,622	19,196	22,674	22,560	-114	-1%
SUTTON	2,749	3,102	3,638	4,590	5,855	6,590	735	13%
UPTON	2,249	2,656	3,127	3,484	3,886	4,270	384	10%
UXBRIDGE*	6,417	7,007	7,789	8,253	8,374	9,720	1346	16%
WORCESTER	193,694	203,486	186,587	176,572	161,799	157,770	-4029	-2%
TOTAL	276,916	301,146	310,266	325,512	320,042	325,867	5825	2%

* 1989 town census was used as the base population for these towns.
Thus, the change is from 1980 to 1989, rather than from 1980 to 1986.

Attleboro, with 1,209 persons per square mile. Douglas has the lowest population density of 120 people per square mile. Table 9 presents a ranking of the study area communities according to density, 1986 federal census estimate, and land area. Worcester accounts for approximately 48 percent of the study area's population but occupies only 10 percent of the land area. Of the study area communities, Worcester, with 38.53 square miles, is the largest, while Millville, with only 4.97 square miles has the least amount of land area.

Sources of Data

Land area for each community was obtained from the Soil Conservation Service, U.S. Department of Agriculture. Density was calculated by dividing the population figures by the land area.

C. Seasonal Population

Seasonal population in the study area is not significant, as shown in Table 10. The overall basin population of 325,867 increases only by 51 (less than one percent) seasonally, with seasonal population reported in Bellingham and Douglas. Appendix 2, Step 4 presents a complete discussion of the methodology used to determine seasonal population factors.

D. Service Population

Of the 325,867 persons living in the study area, 295,237, or 91 percent, obtain their water from a public water supply system. Only Worcester is 100 percent served. The figures in Table 10 represent the percent of the population served by a central water supply system in 1988.

Mendon and Millville are the only communities with no central water supply system. There is a small portion of Mendon serviced by the Milford Water Company whose sources are in the Charles River basin. Otherwise, Mendon and Millville are served by on-site, residential wells and are not expected to install a public system within the study period.

E. Projected Service Area Expansion

In those communities serving less than 100 percent of the population, estimates of service area growth were developed from information obtained from local water supply system managers and from historical data relating to the way service areas develop in response to, or in anticipation of, population growth within a community.

Unless a community has specifically indicated a difference in its expected service population growth, it is assumed, for planning purposes, that:

1. Those communities with a 100 percent service population in 1988 will remain at 100 percent through the planning period.

2. Those communities with a 1988 service population of 90 percent or more will increase 5 percent per decade.

3. Those communities with a service population of less than 90 percent are adjusted on an individual basis, based on estimates of service area growth to 1995, then increased by 10 percent per decade until the year 2020.

Ten of the eighteen communities in the study area are projected to reach 100 percent service population by the year 2020. Three other communities are projected to reach 94 percent or more by 2020.

Table 11 presents the projected service area expansion for those communities whose water systems currently serve less than 100 percent of the population.

Sources of Data

The 1988 service population is that portion of a community that is served by its central water supply system. This information was obtained from OWR Water Supply Questionnaire forms and confirmed through interviews with water superintendents.

The projected service area expansion was reviewed with water superintendents and adjusted if different from the methodology.

F. Population Projections

As discussed above in Section A., the population projections prepared by MISER, MAPC, and local governments and extended by OWR, forecast a population increase of 52,108, or 16 percent between 1986 and 2020, in the study area. Table 8 and Figure 6 detail the population trends in the study area from 1940 to 2020.

All eighteen basin communities are expected to experience an increase in population. Millville, Douglas, and Bellingham are projected to have the largest percentage increases in population between 1986 and 2020. Worcester and North Attleboro are expected to have the largest numerical increase.

Table 12 shows the population projections from 1986 to 2020 for basin communities with numerical and percentage changes.

Sources of Data

Population projections were obtained from MISER, MAPC, and local governments. The projections were based on the 1980 federal census and the 1986 federal census estimate. In this report, OWR used MAPC's projections only for the town of Bellingham. We used the town's projections for 1995 for North Attleboro. For Worcester, OWR worked with the Worcester DPW, Water Operations, and the Office of Planning and Community Development to reach acceptable projections. MAPC population projections were made in five-year increments through 2010. Population projections for year 2020 were derived by extending the projected growth rate between 2000 and 2010 to the year 2020. The MAPC publication, "The Population and Employment Outlook For The Metropolitan Boston Area, A Preliminary Report and Methodology", (March 1988), explains that agency's projection methodology.

Figure 6

BLACKSTONE RIVER BASIN STUDY AREA

POPULATION TRENDS & PROJECTIONS (1940-2020)

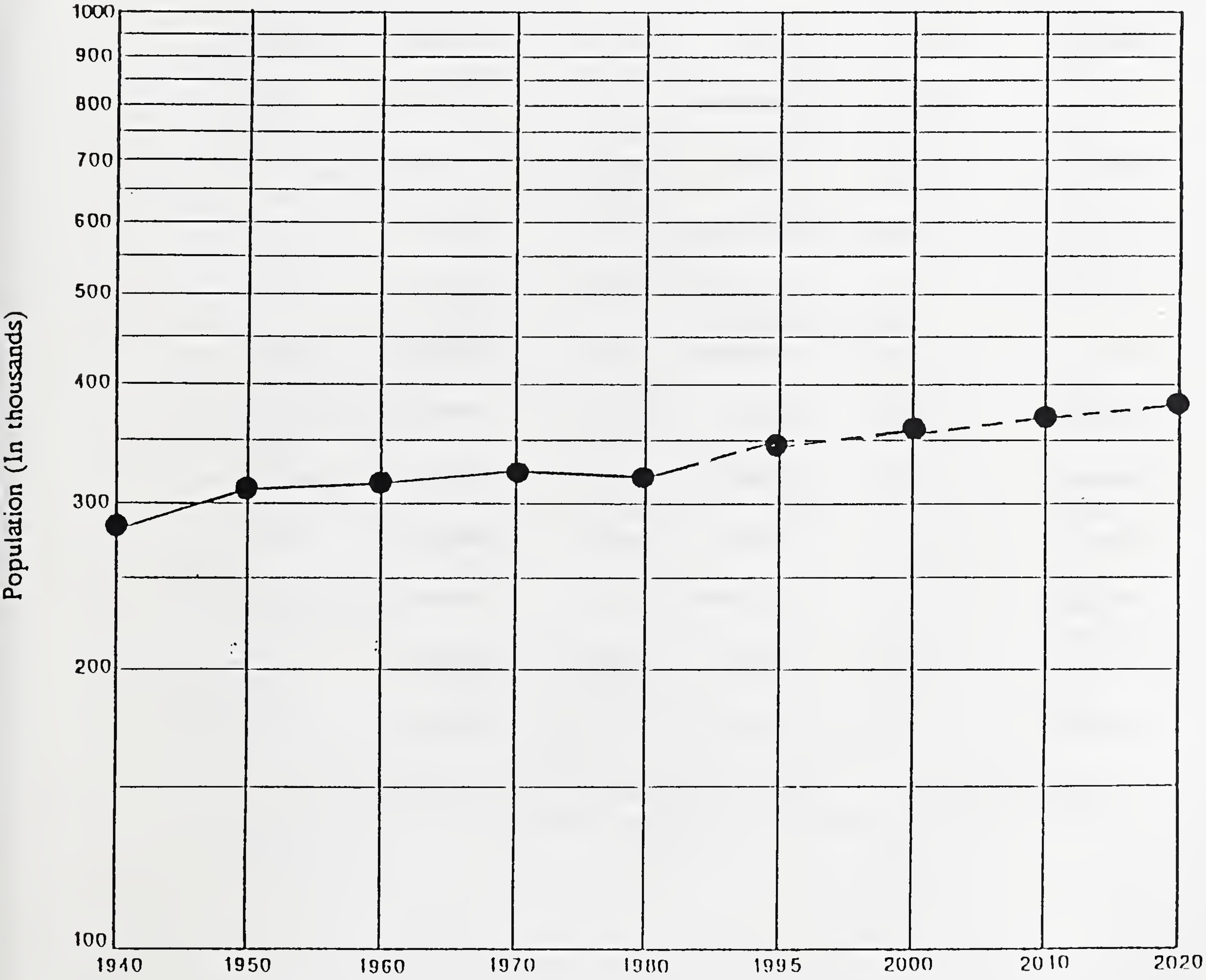


TABLE 9

1986 FEDERAL CENSUS ESTIMATES, LAND AREA AND POPULATION DENSITY
BLACKSTONE RIVER BASIN STUDY AREA
Arranged in Descending Order

1986 FEDERAL CENSUS ESTIMATE		LAND AREA (in square miles)		DENSITY (persons per square mile)	
WORCESTER	157,770	WORCESTER	38.53	WORCESTER	4,095
NO.ATTLEBORO	23,460	DOUGLAS	38.16	NO. ATTLEBORO	1,209
SHREWSBURY	22,560	SUTTON	34.08	SHREWSBURY	1,037
AUBURN	14,580	UXBRIDGE	30.02	AUBURN	887
BELLINGHAM	14,230	LEICESTER	24.64	BELLINGHAM	753
NORTHBRIDGE	12,440	GRAFTON	23.35	HOPEDALE	750
GRAFTON	11,840	UPTON	21.84	MILLBURY	723
MILLBURY	11,840	SHREWSBURY	21.75	NORTHBRIDGE	690
UXBRIDGE*	9,720	BOYLSTON	19.75	BLACKSTONE	624
LEICESTER	9,680	NO. ATTLEBORO	19.40	GRAFTON	507
BLACKSTONE*	7,767	BELLINGHAM	18.91	MILLVILLE	404
SUTTON	6,590	NORTHBRIDGE	18.04	LEICESTER	393
HOPEDALE*	5,500	MENDON	18.01	UXBRIDGE	298
DOUGLAS	4,590	AUBURN	16.43	UPTON	196
UPTON	4,270	MILLBURY	16.37	MENDON	194
BOYLSTON	3,530	BLACKSTONE	11.41	SUTTON	193
MENDON	3,490	HOPEDALE	5.31	BOYLSTON	179
MILLVILLE	2,010	MILLVILLE	4.97	DOUGLAS	120

* 1989 Town Census

TABLE 10
1988 SERVICE POPULATION
BLACKSTONE RIVER BASIN STUDY AREA

COMMUNITY	1986 FED CENSUS ESTIMATE	1988 % SERVICE POPULATION	1988 OUT OF TOWN POPULATION	1988 SEASONAL POPULATION	1988 SERVICE POPULATION
Auburn	14580				
Auburn W.D.		65%			9477
Woodland W.D.		4%			583
Elmhill W.D.		13%			1895
Bellingham	14230	97%		38	13841
Blackstone	7767 *	87%	48		6835
Boylston	3530				
Boylston W.D.		40%			1412
Morningdale W.D.		46%			1624
Douglas	4590	54%		13	2492
Grafton	11840				
Grafton W.D.		57%			6749
So.Grafton W.D.		25%			2960
Hopedale	5500 *	86%			4750
Leicester	9680				
Leicester W.S.D.		35%			3388
Cherry Valley W.D.		46%			4453
Hillcrest W.D.		10%			968
Mendon	3490		NO CENTRAL SUPPLY		
Millbury	11840	83%			9886
Ma. Am. W. Co.					
Millville	2010		NO CENTRAL SUPPLY		
North Attleboro	23460				
N. Attleboro W.D.		95%			22287
King's Grant W.C.		2%			469
Northbridge	12440				
Northbridge		39%			4852
Whitinsville W.C.		45%	192		5790
Shrewsbury	22560	95%			21432
Sutton	6590				
Wilkinsonville W.D.		15%			1000
Manchaug W.D.		6%			395
Upton	4270	55%			2349
Uxbridge	9720 *	78%			7582
Worcester	157770	100%			157770
	325867	91%	240	51	295237

* Town Census

TABLE 11

1988 to 2020 PROJECTED SERVICE POPULATION EXPANSION

BLACKSTONE RIVER BASIN STUDY AREA

COMMUNITY/ Water Department	1988	1995	2000	2010	2020
AUBURN					
Auburn Water Dist.	65	65	70	75	80
Woodland Water Dist.	4	4	4	4	4
Elmhill Water Dist.	13	13	13	13	13
BELLINGHAM					
Bellingham W. Dept.	97	100	100	100	100
BLACKSTONE					
Blackstone W. Dept.	93	93	98	100	100
BOYLSTON					
Boylston W. Dist.	40	40	45	47	47
Morningdale W. Dist.	46	46	51	53	53
DOUGLAS					
Douglas W. Dept.	54	55	56	57	60
GRAFTON					
Grafton Water Dist.	57	57	62	70	73
So. Grafton W. Dist.	25	25	26	26	27
HOPEDALE					
Hopedale W. Dept.	86	90	95	100	100
LEICESTER					
Leicester W.S. Dist.	35	35	40	40	40
Cherry Vall. W. Dist	46	46	50	50	50
Hillcrest W. Dist.	10	10	10	10	10
MENDON	NO CENTRAL SUPPLY				
MILLBURY					
Ma. Am. W. Co.	83	87	92	93	94
MILLVILLE	NO CENTRAL SUPPLY				
NORTH ATTLEBORO					
No.Attleboro W.Div	95	95	97	98	98
King's Grant W. Co.	2	2	2	2	2
NORTHBRIDGE					
Northbridge W.Co.	39	39	44	50	50
Whittinsville W.Co.	45	45	50	50	50
SHREWSBURY					
Shrewsbury W.Dept.	95	95	98	99	100
SUTTON					
Wilkinsonville WD	15	17	20	25	30
Manchaug W.D.	6	6	6	6	6
UPTON					
Upton Water Dept.	55	55	60	65	70
UXBRIDGE					
Uxbridge Water Dept	85	90	95	98	98
WORCESTER					
Worcester Water Dept	100	100	100	100	100
TOTAL SERVICE POPULATION IN THE STUDY AREA	91%	91%	93%	94%	95%

TABLE 12
1980 to 2020 POPULATION PROJECTIONS
BLACKSTONE RIVER BASIN STUDY AREA

COMMUNITY	1980 FEDERAL CENSUS	1986 FED CENSUS ESTIMATE	1995	2000	2010	2020	CHANGES: 1986 TO 2020	
							NUMBER	PERCENT
AUBURN	14,845	14,580	15,135	15,143	15,177	15,965	1,385	9%
BELLINGHAM	14,300	14,230	15,000	16,000	18,500	20,000	5,770	41%
BLACKSTONE *	6,570	7,767	8,746	9,181	9,411	9,910	2,143	28%
BOYLSTON	3,470	3,530	3,569	3,593	3,608	3,784	254	7%
DOUGLAS	3,730	4,590	5,575	6,073	6,461	6,660	2,070	45%
GRAFTON	11,238	11,840	12,537	12,765	12,958	13,571	1,731	15%
HOPEDALE *	3,905	5,500	5,537	5,573	5,804	6,102	602	11%
LEICESTER	9,446	9,680	9,844	9,951	10,012	10,526	846	9%
MENDON	3,108	3,490	3,759	3,978	4,099	4,284	794	23%
MILLBURY	11,808	11,840	11,693	11,752	11,747	12,373	533	5%
MILLVILLE	1,693	2,010	2,684	2,694	2,858	2,968	958	48%
NO.ATTLEBORO	21,095	23,460	26,781	28,863	29,949	31,684	8,224	35%
NORTHBRIDGE	12,246	12,440	12,869	12,888	12,957	13,630	1,190	10%
SHREWSBURY	22,674	22,560	22,792	22,696	22,706	23,910	1,350	6%
SUTTON	5,855	6,590	7,284	7,673	7,929	8,281	1,691	26%
UPTON	3,886	4,270	4,484	4,692	4,799	5,024	754	18%
UXBRIDGE *	8,374	9,720	10,556	11,275	11,557	12,170	2,450	25%
WORCESTER	161,799	157,770	167,192	167,383	168,395	177,133	19,363	12%
TOTALS	320,042	325,867	346,037	352,173	358,927	377,975	52,108	16%

* 1989 Town Census used instead of 1986 Federal Census Estimate

V. PROJECTED WATER DEMANDS

A. Introduction

This chapter discusses the projected average and maximum day demands for the study area through the year 2020. The average day demand (ADD) is the amount of water used by a community during the year, divided by 365 days (366 in a leap year). Because the amount of water used varies significantly from season to season, the average figure does not reflect the actual water needs of the system. The maximum day demand (MDD) represents the highest level of demand on the water supply system and is an important figure for planning future water system requirements and evaluating the potential for water conservation in a community. The MDD estimation is especially important for water supply systems that depend heavily on groundwater because water supply wells have limited pumping capacity and storage capacity may be limited. The comparison of ADD and MDD projections provide a useful picture of water demand in each community.

Projections of demand, combined with an assessment of available supplies, can assist communities in planning the direction of their future development. This Volume I study assesses the demand, Volume II will analyze the basin water resource situation. To project demand through the study period, OWR used three figures: base demand, gallons per capita per day (GPCD), and the MDD/ADD ratio.

B. Base Demand

In reviewing water use in many Massachusetts communities, OWR has found that basing future demand projections on a long historical trend of water use gives incorrectly low results in those communities where population, employment, and water use have been experiencing recent growth. Conversely, using only the most recent year's water demand figures may provide inaccurate data due to one-time events requiring large quantities of water, such as a very warm dry summer. To modify these influences and still reflect a reasonable trend, OWR has used the average water demand for three years (1986 to 1988) as the basis for projections. This average is called Base Demand. In slower growing communities, it was found that the three-year average is similar to the long-term trend. The base demand varied from the 1986-1988 base period for three communities. In the town of Blackstone, the estimated 1989 ADD, was found to reflect the most accurate basis for projections. In the Grafton Water Distict and Millbury's Massachusetts American Water Company, the 1988 ADD was found to reflect the most accurate basis for projections.

Some communities may experience a significant change in water demand during the planning period if, for example, a large water-intensive industry or processing facility opens or closes in the area. Where this information is known, the anticipated change in water was added or subtracted from the projected water use for the community. Four Blackstone communities were in this category. Projected water use for the Auburn Water District was increased after extensive discussions with the town planner revealed significant proposed commercial development. Bellingham's projected water use was increased due to the expected growth in commercial and industrial use according to our discussions with community and state economic officials. Projections for the Morningdale Water District in Boylston were also increased as planned and approved commercial development is expected to significantly increase water use. Worcester's Water Operations is expected to require more water for distribution to its growing population as well as to meet the increased demand of the other water supply systems it supplies, such as Auburn's Woodland and Elm Hill Water Districts and the town of Holden.

The base average day demand (1986-1988) for the study area is 42.04 mgd. Demand is projected to increase 45 percent to 60.98 mgd by the year 2020. The maximum day demand of the study area is projected to increase by 47 percent to 96.61 mgd from the 1986-1988 base maximum day demand of 65.87 mgd. These increases are due to a projected significant increase in commercial and industrial water use in several communities as well as projected population increases.

C. Gallons Per Capita Per Day

In order to develop water demand projections for a public water supply system, certain assumptions must be made regarding the gallons consumed per capita per day (GPCD). GPCD varies from community to community in Massachusetts depending on the type of water use (industrial, residential, etc.), water restrictions, leakage and conservation. A survey of community GPCD in the Blackstone River basin from 1980 to 1988 shows that there is no set pattern. Percentage changes in GPCD during this time period ranged from an increase of 108 percent to a decrease of 68 percent, with a median increase of 2 percent. This means that half of the towns have experienced GPCD increases greater than two percent in the past eight years, and half of the towns are experiencing a decline in GPCD. For example, Worcester, with several large industrial users has a base GPCD of 168, while Douglas, with mainly residential users, has a base GPCD of about 92 (see Table 13). A community's GPCD also varies from year to year depending on changes in precipitation, type of water use, attitudes concerning conservation, and prices. A residential town will most likely see a rise in GPCD during a dry year due to increased outdoor watering.

For water demand projection purposes, a conservative five percent per decade increase in GPCD is assumed. Continued commercial, industrial and residential growth in some communities will keep an upward pressure on GPCD in the study area, while changes in the industrial base in other communities

TABLE 13
1980 TO 1988 GPCD CHANGES
BLACKSTONE RIVER BASIN STUDY AREA

COMMUNITY/ AGENCY	1986-1988 BASE GPCD	1980 GPCD	1988 GPCD	NUMBER CHANGE	PERCENT CHANGE
Auburn					
Auburn W.D.	131	107	131	24	22%
Woodland W.D.	51	51	51	0	0%
Elmhill W.D.	37	115	37	-78	-68%
Bellingham	99	74	107	33	45%
Blackstone	92	61	88	27	44%
Boylston					
Boylston W.D.	156	108	177	69	64%
Morningdale W.D.	135	94	129	35	37%
Douglas	92	69	96	27	39%
Grafton					
So.Grafton W.D.	61	64	61	-3	-5%
Grafton W.D.	113	121	113	-8	-7%
Hopedale	105	143	99	-44	-31%
Leicester					
Leicester W.S.D.	59	83	59	-24	-29%
Cherry Valley W.D	58	72	58	-14	-19%
Hillcrest W.D.	72				
Mendon					
Millbury					
Ma. Am. W. Co.	169	202	169	-33	-16%
Millville					
Northbridge					
Northbridge W.C.	91	111	231	120	108%
Whitinsville W.C.					
North Attleboro					
N. Attleboro W.D.	111	130	127	-3	-2%
King's Grant W.C.	107	146	149	3	2%
Shrewsbury	148	125	149	24	19%
Sutton					
Wilkinsonville W.	90	122	80	-42	-34%
Manchaug W.D.	76	49	76	27	55%
Upton	123	104	115	11	11%
Uxbridge	100	154	99	-55	-36%
Worcester	168	159	170	11	7%
TOTAL SERVICE AREA	142	139	145	6	4%

can cause a decline in GPCD. Also, water conservation efforts have served to limit water use increases. Another factor limiting growth of GPCD is the recent change in the plumbing code mandating the use of water saving devices in new construction and renovations.

D. Base MDD and the MDD/ADD Ratio

Projecting the maximum day demand (MDD) for a public water supply system is important since future water supply, distribution and storage systems must be able to deliver water under MDD conditions. As stated previously, water supply systems that depend heavily on ground water are most vulnerable to MDD problems. Surface water sources offer more flexibility in meeting MDD as long as the water levels are high enough to prevent water quality problems. Base MDD is the average of the reported maximum day demands for a study area community during the three year period from 1986 to 1988.

To project maximum day demands, an MDD to ADD ratio is calculated by dividing a community's MDD by its ADD for each year of the three year base period (1986 to 1988) and then averaging these results to obtain a base MDD/ADD ratio. This base ratio is then multiplied by the projected ADD to obtain the projected MDD.

The maximum day demand in the study area is projected to increase from the base 65.87 mgd to 96.61 mgd by 2020, an increase of 47 percent. The MDD projections assume that the base MDD/ADD ratio will remain the same over the planning period. Fluctuations in the ratio will influence the accuracy of the maximum day demands in the summer. Unpredictable events, such as major leaks or a drought will also influence the MDD/ADD ratio.

Table 14 shows the ADD, MDD, and MDD/ADD ratio for each study area community. Tables 15 and 16 list the projected average day and maximum day demands from 1995 to 2020, including the volume and percentage increases.

D. Water Demand Projection Assumptions

The projections of water demand are based on OWR's assumptions of what will be occurring in the Blackstone River Basin study area during the next 30 years. The population projections prepared by MISER, MAPC and local governments were based on state and regional growth patterns. OWR's extension of these projections are adjusted with input from local officials concerning specific growth patterns and restrictions. These studies project an overall average increase in population of 16 percent for the study area during the planning period of 1986 to 2020.

Each central water supply system manager was asked about

TABLE 14
AVERAGE DAY DEMANDS, MAXIMUM DAY DEMANDS, MDD/ADD RATIO
1986 TO 1988 AND BASE WATER WATER DEMAND
BLACKSTONE RIVER BASIN STUDY AREA

	1986			1987			1988				1986-1988	
COMMUNITY/ Agency	ADD	MDD	MDD/ADD RATIO	ADD	MDD	MDD/ADD RATIO	ADD	MDD	MDD/ADD RATIO	BASE ADD	BASE MDD	MDD/ADD RATIO
AUBURN												
Auburn Water Dist.	1.24	1.83	1.48	1.24	2.20	1.77	1.24	2.25	1.81	1.24	2.09	1.69
Woodland Water Dist.	0.03	0.05	1.67	0.03	0.05	1.67	0.03	0.05	1.67	0.03	0.05	1.67
Elmhill Water Dist.	0.06	0.09	1.50	0.07	0.10	1.43	0.07	0.10	1.43	0.07	0.10	1.43
BELLINGHAM												
Bellingham W. Dept.	1.27	2.05	1.61	1.35	2.22	1.64	1.48	2.23	1.50	1.37	2.16	1.58
BLACKSTONE												
Blackstone W. Dept.	0.51	0.89	1.75	0.56	1.67	2.98	0.60	1.10	1.83	0.63 (1)	1.22	2.19
BOYLSTON												
Boylston W. Dist.	0.20	0.28	1.40	0.21	0.29	1.38	0.25	0.38	1.52	0.22	0.32	1.43
Morningdale W. Dist.	0.21	0.32	1.52	0.23	0.35	1.52	0.21	0.32	1.52	0.22	0.33	1.52
DOUGLAS												
Douglas W. Dept.	0.21	0.39	1.86	0.24	0.65	2.71	0.24	0.33	1.38	0.23	0.46	1.98
GRAFTON												
Grafton Water Dist.	0.66	1.46	2.21	0.73	1.48	2.03	0.76	1.35	1.78	0.76 (2)	1.43	2.01
So. Grafton W. Dis	0.20	0.30	1.50	0.17	0.26	1.53	0.18	0.27	1.50	0.18	0.28	1.56
HOPEDALE												
Hopedale W. Dept.	0.60	1.03	1.72	0.43	0.86	2.00	0.47	0.60	1.28	0.50	0.83	1.66
LEICESTER												
Leicester W.S. Dist.	0.19	0.27	1.42	0.20	0.27	1.35	0.20	0.27	1.35	0.20	0.27	1.35
Cherry Vall. W. Dist	0.24	0.44	1.83	0.27	0.43	1.59	0.26	0.49	1.88	0.26	0.45	1.77
Hillcrest W. Dist.	0.06	0.09	1.50	0.07	0.11	1.57	0.07	0.10	1.43	0.07	0.10	1.50
MENDON	No Central Supply											
MILLBURY												
Millbury Ma.Am.W.Co.	1.15	2.13	1.85	1.09	1.63	1.50	1.67	2.85	1.70	1.67 (2)	2.85	1.71
MILLVILLE	No Central Supply											
NORTH ATTLEBORO												
No.Attleboro W.Div	2.06	3.98	1.93	2.51	5.15	2.05	2.84	5.41	1.90	2.47	4.85	1.96
King's Grant W. Co.	0.04	0.06	1.50	0.05	0.08	1.60	0.07	0.13	1.86	0.05	0.09	1.80
NORTHBRIDGE												
Northbridge W.Co.	0.42	0.63	1.50	0.55	0.83	1.51	0.36	0.54	1.50	0.44	0.67	1.52
Whittinsville W.Co.	0.58	1.61	2.78	0.59	1.59	2.69	0.76	1.89	2.49	0.64	1.70	2.65
SHREWSBURY												
Shrewsbury W.Dept.	3.13	5.07	1.62	3.20	6.13	1.92	3.19	6.10	1.91	3.17	5.77	1.82
SUTTON												
Wilkinsonville WD	0.10	0.13	1.30	0.08	0.14	1.75	0.08	0.14	1.75	0.09	0.14	1.56
Manchaug W.D.	0.03	0.05	1.67	0.03	0.05	1.67	0.03	0.05	1.67	0.03	0.05	1.67
UPTON												
Upton Water Dept.	0.34	0.51	1.50	0.27	0.41	1.52	0.27	0.50	1.85	0.29	0.47	1.62
UXBRIDGE												
Uxbridge Water Dept	0.69	0.93	1.35	0.67	1.11	1.66	0.75	1.39	1.85	0.76 (1)	1.14	1.62
WORCESTER												
Worcester Water Dept	26.39	36.63	1.39	26.17	37.61	1.44	26.78	39.92	1.49	26.45 (3)	38.05	1.44
TOTAL	40.61	61.22		41.01	65.67		42.86	68.76		42.04	65.87	

(1) 1989 ADD (2) 1988 ADD (3) Also sold 0.37 mgd to other water supply systems (4) 1988 MDD

planned system expansion during the next 30 year period. Table 13, as specified earlier, shows the service area expansion.

E. Water Demand Projection Methodology

The OWR water demand projection methodology outlined in Appendix 2 reflects anticipated changes in service population, per capita demand, demand management, and characteristics of the individual communities.

Appendix 2 contains a detailed explanation of each step in the methodology. Table 17 presents the step by step analysis used to calculate projected 1995 through 2020 water demands.

TABLE 15
1995 TO 2020 AVERAGE DAY DEMAND PROJECTIONS (mgd)
BLACKSTONE RIVER BASIN STUDY AREA

COMMUNITY/ AGENCY	BASE 1986-1988 ADD	-------Projections------- 1995 ADD	2000 ADD	2010 ADD	2020 ADD	Change BASE to 2020 ADD	Percent
AUBURN							
Auburn Water Dist.	1.24	1.42	1.61	1.79	2.07	0.83	67%
Woodland Water Dist.	0.03	0.03	0.03	0.03	0.04	0.01	33%
Elmhill Water Dist.	0.07	0.07	0.08	0.08	0.09	0.02	29%
BELLINGHAM							
Bellingham W. Dept.	1.37	2.06	2.52	3.14	3.38	2.01	147%
BLACKSTONE							
Blackstone W. Dept.	0.63 (1)	0.77	0.88	0.96	1.06	0.43	68%
BOYLSTON							
Boylston W. Dist.	0.22	0.23	0.26	0.29	0.32	0.10	45%
Morningdale W. Dist.	0.22	0.32	0.38	0.43	0.46	0.24	109%
DOUGLAS							
Douglas W. Dept.	0.23	0.29	0.33	0.37	0.42	0.19	83%
GRAFTON							
Grafton W. Dist.	0.76 (2)	0.82	0.94	1.12	1.28	0.52	68%
So. Grafton W. Dist.	0.18	0.20	0.21	0.23	0.26	0.08	44%
HOPEDALE							
Hopedale W. Dept.	0.50	0.54	0.59	0.67	0.74	0.24	48%
LEICESTER							
Leicester W.S. Dist.	0.20	0.21	0.25	0.26	0.29	0.09	45%
Cherry Vall. W. Dist	0.26	0.27	0.31	0.32	0.35	0.09	35%
Hillcrest W. Dist.	0.07	0.07	0.08	0.08	0.09	0.02	29%
MENDON		NO CENTRAL SUPPLY					
MILLBURY							
Millbury Ma.Am.W.Co.	1.67 (2)	1.76	1.92	2.03	2.26	0.59	35%
MILLVILLE		NO CENTRAL SUPPLY					
NORTH ATTLEBORO							
No.Attleboro W.Div	2.47	2.89	3.26	3.58	3.96	1.49	60%
King's Grant W. Co.	0.05	0.06	0.06	0.07	0.08	0.03	60%
NORTHBRIDGE							
Northbridge W.Co.	0.44	0.47	0.54	0.65	0.71	0.27	62%
Whittinsville W.Co.	0.64	0.66	0.75	0.79	0.87	0.23	36%
SHREWSBURY							
Shrewsbury W.Dept.	3.17	3.28	3.45	3.66	4.07	0.90	28%
SUTTON							
Wilkinsonville WD	0.09	0.11	0.15	0.20	0.26	0.17	189%
Manchaug W.D.	0.03	0.03	0.04	0.04	0.04	0.01	33%
UPTON							
Upton Water Dept.	0.29	0.31	0.37	0.42	0.50	0.21	72%
UXBRIDGE							
Uxbridge Water Dept	0.76 (1)	0.98	1.13	1.25	1.37	0.61	80%
WORCESTER							
Worcester Water Dept	26.45 (3)	30.60	31.33	32.92	36.02	9.57	36%
TOTAL	42.04	48.45	51.43	55.38	60.98	18.94	45%

(1) 1989 ADD (2) 1988 ADD

(3) Also sold 0.37 mgd to other water supply systems

TABLE 16
1995 TO 2020 MAXIMUM DAY DEMAND PROJECTIONS (mgd)
BLACKSTONE RIVER BASIN STUDY AREA

	BASE	-------Projections-------					
COMMUNITY/ AGENCY	1986-1988 MDD	1995 MDD	2000 MDD	2010 MDD	2020 MDD	Change BASE to 2020 MDD	PERCENT
AUBURN							
Auburn Water Dist.	2.09	2.40	2.71	3.02	3.50	1.41	67%
Woodland Water Dist.	0.05	0.05	0.05	0.06	0.06	0.01	20%
Elmhill Water Dist.	0.10	0.11	0.11	0.11	0.13	0.03	30%
BELLINGHAM							
Bellingham W. Dept.	2.16	3.25	3.98	4.96	5.34	3.18	147%
BLACKSTONE							
Blackstone W. Dept.	1.22	1.69	1.92	2.10	2.31	1.09	89%
BOYLSTON							
Boylston W. Dist.	0.32	0.33	0.38	0.42	0.46	0.14	44%
Morningdale W. Dist.	0.33	0.48	0.58	0.66	0.70	0.37	112%
DOUGLAS							
Douglas W. Dept.	0.46	0.57	0.65	0.74	0.84	0.38	83%
GRAFTON							
Grafton Water Dist.	1.43	1.66	1.88	2.26	2.58	1.15	80%
So. Grafton W. Dist.	0.28	0.30	0.33	0.35	0.40	0.12	43%
HOPEDALE							
Hopedale W. Dept.	0.83	0.89	0.97	1.12	1.23	0.40	48%
LEICESTER							
Leicester W.S. Dist.	0.27	0.28	0.33	0.35	0.39	0.12	44%
Cherry Vall. W. Dist.	0.45	0.48	0.54	0.57	0.63	0.18	40%
Hillcrest W. Dist.	0.10	0.11	0.11	0.12	0.13	0.03	30%
MENDON		NO CENTRAL SUPPLY					
MILLBURY							
Millbury Ma.Am.W.Co.	2.85 (1)	3.01	3.28	3.47	3.86	1.01	35%
MILLVILLE		NO CENTRAL SUPPLY					
NORTH ATTLEBORO							
No.Attleboro W.Div	4.85	5.66	6.39	7.01	7.76	2.91	60%
King's Grant W. Co.	0.09	0.11	0.12	0.13	0.14	0.05	56%
NORTHBRIDGE							
Northbridge W.Co.	0.67	0.71	0.82	0.98	1.08	0.41	61%
Whittinsville W.Co.	1.70	1.74	1.98	2.09	2.30	0.60	35%
SHREWSBURY							
Shrewsbury W.Dept.	5.77	5.97	6.29	6.66	7.40	1.63	28%
SUTTON							
Wilkinsonville WD	0.14	0.18	0.23	0.31	0.40	0.26	186%
Manchaug W.D.	0.05	0.06	0.06	0.07	0.07	0.02	40%
UPTON							
Upton Water Dept.	0.47	0.51	0.59	0.69	0.81	0.34	72%
UXBRIDGE							
Uxbridge Water Dept	1.14	1.58	1.83	2.02	2.23	1.09	96%
WORCESTER							
Worcester Water Dept	38.05	44.06	45.12	47.41	51.87	13.82	36%
TOTAL	65.87	76.20	81.25	87.67	96.61	30.74	47%

(1) 1988 MDD

TABLE 17

2020 WATER DEMAND PROJECTIONS

BLACKSTONE RIVER BASIN STUDY AREA

COMMUNITY	1986 FED CENSUS ESTIMATE	1988 % SERV. POP.	1988 OUT-OF-TOWN POP.	1988 SEASONAL POP.	1988 SERVICE POP.	1986-1988 BASE ADD	1986-1988 GPCD	2020 POP. PROJ.	2020 MINIMUM SERV. POP.	2020 BASE ADD	2020 PERCENT SERV POP	2020 ADJ SERVICE POP.	2020 ADJ. ADD	2020 GPCD	2020 ADJ. ADD (1)	SIGNIFICANT CHANGE IN WATER USE	2020 ADJ. ADD (2)	1986-1988 MDD	1986-1988 MDD/ADD	2020 MDD
Auburn	14580							15965												
Auburn W.D.		65%			9477	1.24	131		10377	1.36	80%	12772	1.67	150	1.92	0.15	2.07	2.09	1.69	3.50
Woodland W.D.		4%			583	0.03	51		639	0.03	4%	639	0.03	59	0.04		0.04	0.05	1.67	0.06
Elmhill W.D.		13%			1895	0.07	37		2075	0.08	13%	2075	0.08	42	0.09		0.09	0.10	1.43	0.13
Bellingham	14230	97%		38	13841	1.37	99	20000	19438	1.92	100%	20038	1.98	114	2.28	1.10	3.38	2.16	1.58	5.34
Blackstone	7767 (1)	87%	48		6835	0.63 (2)	92	9910	8707	0.80	100%	9958	0.92	106	1.06		1.06	1.22	2.19	2.31
Boylston	3530							3784												
Boylston W.D.		40%			1412	0.22	156		1514	0.24	47%	1778	0.28	179	0.32		0.32	0.32	1.43	0.46
Morningdale W.D.		46%			1624	0.22	135		1741	0.24	53%	2006	0.27	156	0.31	0.15	0.46	0.33	1.52	0.70
Douglas	4590	54%		13	2492	0.23	92	6660	3609	0.33	60%	3996	0.37	106	0.42		0.42	0.46	1.98	0.84
Grafton	11840							13571												
Grafton W.D.		57%			6749	0.76 (3)	113		7735	0.87	73%	9907	1.12	130	1.28		1.28	1.43	2.01	2.58
So.Grafton W.D.		25%			2960	0.18	61		3393	0.21	27%	3664	0.22	70	0.26		0.26	0.28	1.56	0.40
Hopedale	5500 (1)	86%			4750	0.50	105	6102	5270	0.55	100%	6102	0.64	121	0.74		0.74	0.83	1.66	1.23
Leicester	9680							10526												
Leicester W.S.D.		35%			3388	0.20	59		3684	0.22	40%	4210	0.25	68	0.29		0.29	0.27	1.35	0.39
Cherry Valley W.D.		46%			4453	0.26	58		4842	0.28	50%	5263	0.31	67	0.35		0.35	0.45	1.77	0.63
Hillcrest W.D.		10%			968	0.07	72		1053	0.08	10%	1053	0.08	83	0.09		0.09	0.10	1.50	0.13
Mendon	3490		NO CENTRAL SUPPLY					4284												
Millbury	11840	83%			9886	1.67 (3)	169	12373	10331	1.75	94%	11631	1.96	194	2.26		2.26	2.85 (4)	1.71	3.86
Ma. Am. W. Co.																				
Millville	2010		NO CENTRAL SUPPLY					2968												
North Attleboro	23460							31684												
N. Attleboro W.D.		95%			22287	2.47	111		30100	3.34	98%	31050	3.44	127	3.96		3.96	4.85	1.96	7.76
King's Grant W.C.		2%			469	0.05	107		634	0.07	2%	634	0.07	123	0.08		0.08	0.09	1.80	0.14
Northbridge	12440							13630												
Northbridge W.C.		39%			4852	0.44	91		5316	0.48	50%	6815	0.62	104	0.71		0.71	0.67	1.52	1.08
Whitinsville W.C.		45%	192		5790	0.64	111		6326	0.70	50%	6815	0.75	127	0.87		0.87	1.70	2.65	2.30
Shrewsbury	22560	95%			21432	3.17	148	23910	22715	3.36	100%	23910	3.54	170	4.07		4.07	5.77	1.82	7.40
Sutton	6590							8281												
Wilkinsonville W.D.		15%			1000	0.09	90		1256	0.11	30%	2484	0.22	104	0.26		0.26	0.14	1.56	0.40
Manchaug W.D.		6%			395	0.03	76		497	0.04	6%	497	0.04	87	0.04		0.04	0.05	1.67	0.07
Upton	4270	55%			2349	0.29	123	5024	2763	0.34	70%	3517	0.43	142	0.50		0.50	0.47	1.62	0.81
Uxbridge	9720 (1)	78%			7582	0.76 (2)	100	12170	9493	0.95	98%	11927	1.20	115	1.37		1.37	1.14	1.62	2.23
Worcester	157770	100%			157770	26.45 (5)	168	177133	177133	29.70	100%	177133	29.70	193	34.15	1.87 (6)	36.02	38.05	1.44	51.87
TOTAL	325867		240	51	295237	42.04		377975	340638	48.04		359873	50.18		57.71	3.27	60.98	65.87		96.61

(1) 1989 Town Census (2) 1989 AD (3) 1988 ADD (4) 1988 MDD (5) Also sold 0.37 mgd to other water supply systems (6) projected demand of other water supply systems supplied by Worcester

APPENDIX 1

Blackstone River Basin Study Area

Water Supply Agencies

Community and Local Water Resources Management Official	Agency	Contact
AUBURN Michael O'Hara Town Planner 104 Central Street (508) 832-7704	Auburn Water District	Daniel S. Horgan, Supt. 75 Church St. P.O. Box 187 Auburn, MA 01501 (508) 832-5336
	Woodland Water Dist.	William Orrell Superintendent 17 Forest Drive Auburn, MA 01501 (508) 754-2372
		Paul Noak 2 Alpine Trail Auburn, MA 01501
	Elmhill Water Dist.	Robert Raymond Water Commissioner 55 Jerome Avenue Auburn, MA 01501 (508) 755-5448
BELLINGHAM Chm. Bd. of Selectmen 1 Mechanic Street Bellingham, MA 02019 (508) 966-0990	Bellingham W. Dept.	VACANT Superintendent 200 Wrentham Road Bellingham, MA 02019 (508) 883-7803
BLACKSTONE Chm. Bd. of Selectmen 15 St. Paul St. Blackstone, MA 01504 (508) 883-1500	Blackstone W. Dept.	Thomas F. Devlin Superintendent 15 St. Paul Street Blackstone, MA 01504 (508) 883-1500

Community and Local Water Resources Management Official	Agency	Contact
BOYLSTON Chm. Bd. of Selectmen 84 Main St. Boylston, MA 01505 (508) 869-2234	Boylston W. Dist.	Ralph O. Wagner, Jr. Superintendent 74 Main Street Boylston, MA 01505 (508) 869-2104
	Morningdale W. Dist.	Ralph O. Wagner, Jr. (Same as above)
DOUGLAS Joseph Saster Water Commission Main Street Douglas, MA 01516 (508) 476-3328/2400	Douglas Water Department	Frederick H. Hashey, Jr. Superintendent P.O. Box 624 E. Douglas, MA 01516 (508) 476-2400
GRAFTON George Prunier 30 Providence Road Grafton, MA 01519 (508)839-5335/4408	So. Grafton Water District	Chester Hospod Superintendent 357 Providence Road So. Grafton, MA 01560 (508) 839-6867
	Grafton Water District	Matthew Pearson Superintendent 30 Providence Road Grafton, MA 01519 (508) 839-2302
HOPEDALE John A. Hayes, Town Adm. P.O. Box 7 Hopedale, MA 01747 (508) 478-2140	Hopedale Water Dept.	Leonard J. Barrett Foreman P.O. Box 7 Hopedale, MA 01747 (508) 478-2140

Community and Local Water Resources Management Official	Agency	Contact
LEICESTER	Leicester W.S. Dist.	Frank W. Lyon Superintendent P.O. Box 86 Leicester, MA 01524 (508) 892-8484
Chm. Bd of Selectmen Town Hall Washington St. Leicester, MA 01524 (508) 892-8133	Cherry Valley & Rochedale Water District	Michael F. Knox Superintendent P.O. Box 23 Leicester, MA 01524 (508) 892-9616
	Hillcrest W. Dist.	Jeffrey Smith Superintendent 381 Pleasant Street Leicester,MA 01524 (508) 892-3251
MENDON	NO CENTRAL SUPPLY	
Chm. Bd of Selectmen 20 Main Street Mendon, MA 01756 (508) 473-2312		
MILLBURY	Mass. American Water Co.	Mark Dana, Mgr. Eileen Commane, Chemist 8 South Main St. P.O. Box 272 Millbury, MA 01527 (508) 865-0555
Kathleen Klein Conservation Commisssion 127 Elm Street Millbury, MA 01527 (508) 865-0287		
MILLVILLE	NO CENTRAL SUPPLY	
Daniel Concaugh Adm. Asst. 170 Main Street Millville, MA 01529		
NORTH ATTLEBORO	No. Attleboro Water Dept.	Brian H. Burtwell Superintendent 240 South Street No. Attleboro, MA 02760 (508) 695-1869
	King's Grant Water Co.	John P. Brady Superintendent Irene O'Malley, Owner 839 Newport Ave. So. Attleboro, MA 02703 (508) 761-8531

Community and Local Water Resources Management Official	Agency	Contact
NORTHBRIDGE Samuel Carpinetti Bd. of Health (same as Water Dept.)	Northbridge Water Dept.	Samuel R. Carpinetti P.O. Box 188 44 Lake Street Northbridge, MA 01588 (508) 234-7358
	Whitinsville Water Co.	same as Northbridge Water Dept.
SHREWSBURY Robert Tozeski (same as Water Supt.)	Shrewsbury Water Dept.	Robert Tozeski Superintendent 100 Maple Avenue Shrewsbury, MA 01545 (508) 845-3413
SUTTON Richard Wharton, Jr. Town Engineer 4 Uxbridge Road Sutton, MA 01590 (508) 865-3952	Wilkinsonville Water District	Jack Hickey Treasurer 2 Bashaw Road Sutton, MA 01527 (508) 865-1563 OR Joseph Hospod 108 Elmwood So. Grafton, MA 01560
	Manchaug Water District	Jane LaForce Chairman P.O. Box 173 Manchaug, MA 01526 (508) 476-7081
UPTON Chm., Bd. of Selectmen One Main Street Upton, MA 01568 (508) 529-6901	Upton Water Department	Leo Morin, Supt. Charles Marsden, Comm. P.O. Box 75 Upton, MA 01568 (508) 529-3993

Community and Local Water Resources Management Official	Agency	Contact
UXBRIDGE Lawrence Bombara Bd. of Public Works South Main St. Uxbridge, MA 01569 (508) 278-6013	Uxbridge DPW, Water Div.	Joseph Darcy Supervisor Uxbridge DPW, Water Div. Blackstone Street Uxbridge, MA 01569 (508) 278-2175
WORCESTER Kathleen Klein Water Resources Coordinator 18 E. Worcester St. Worcester, MA 01604	Worcester DPW, Water Operation	Konstantin Eliadi Director 18 E. Worcester St. Worcester, MA 01604 (508) 799-1485

APPENDIX 2

Water Demand Projection Methodology

This appendix describes the nineteen steps in the methodology used to project water demand for the period 1995-2020. The purpose for each step, source of information, and formula, if applicable, are described. The projected water demands produced by this methodology are accurate provided that the assumptions underlying the various steps remain valid. For example, the methodology uses population projections prepared by the Massachusetts Institute for Social and Economic Reasearch (MISER), local governments, and for the town of Bellingham, the Metropolitan Area Planning Council (MAPC). If actual population growth is substantially different from these projections, the actual water use will differ from projected demands.

The assumptions built into this methodology are based on an analysis of future trends developed from literature, consultants' reports and a review of recent experience of water demand fluctuations and conservation efforts in Massachusetts.

The nineteen steps are as follows:

1. Communities Included in the Study Area
2. 1986 federal census estimate
3. 1988 percent service population
4. 1988 seasonal population
5. 1988 out-of-town population
6. 1988 base service population
7. 1986-1988 base average day demand
8. 1986-1988 GPCD
9. 2020 population projections
10. 2020 minimum service population
11. 2020 base average day demand
12. 2020 increase in percent service population
13. 2020 adjusted service population
14. 2020 GPCD
15. significant changes anticipated in water use
16. Adjusted 2020 ADD
17. 1986-1988 maximum day demand
18. 1986-1988 MDD to ADD ratio
19. 2020 maximum day demand

STEP 1: Communities Included in Study Area

A community is included in the river basin study area if more than 50 percent of its area is located within the basin, or if it uses the basin as a source of public water supply. Therefore, communities that are not geographically located within the basin may be included in the study area.

STEP 2: 1986 Federal Census Estimate

The 1986 federal census estimates, obtained from the U.S. Bureau of Census, are used as the most recent estimates of population. The estimates are prepared using procedures that rely on measuring components of population change. Birth and death by residence are used to estimate natural increase; federal income tax returns are used to estimate net internal migration; reported immigration statistics are used to estimate net migration.

STEP 3: 1988 Service Population

This figure represents the percentage of a community's population that is served by a public water supply system in 1986. A 90 percent service population means that 90 percent of the community is served by a public supply system, and the other 10 percent is self-supplied (relying entirely on individual private wells) or is being supplied by connections to other water systems.

This figure is obtained from the updated Municipal Water Resources Management Plan - Phase II questionnaire and confirmed by DWR personnel in interviews with water superintendents.

STEP 4: 1988 Seasonal Population

Some study area communities have seasonal populations. In order to calculate an accurate annual average gallons per capita per day (GPCD) and future water demand, it is necessary to estimate an adjusted service population which reflects the increased seasonal population. For planning purposes, it is assumed that the seasonal populations of the basin will remain constant throughout the planning period.

Local water superintendents or community planning boards usually can estimate the peak seasonal population, but have little hard data with which to estimate the distribution of the seasonal population. Gordian Associates (1979), in their analysis of Regional Solid Waste Alternatives for Martha's Vineyard, found that the relationship between the winter and summer populations can be represented by a bell-shaped curve, with the July population being the highest point on the curve. The August population is approximately 75 percent of the peak July population, and the September and June populations are 25 percent of the July peak. From October to May the population remains constant at the year-round figure. Gordian Associates developed a formula which approximates this relationship and, in simple terms, states that every 100 seasonal residents is equivalent to 18.75 persons using water service on a year-round basis.

Peak seasonal population was obtained from the Municipal Water Resources Management Plan - Phase II questionnaires. This figure is multiplied by 0.1875 to obtain the seasonal population factor. In the Blackstone River basin, the seasonal population is insignificant.

STEP 5: Out-of-Town Population

Out-of-town population is defined as any population outside of a community that is served by the community's public water supply system. Care is taken to subtract this population from the service population of their resident communities to avoid double-counting. For planning purposes, it is assumed that the out-of-town population of the basin will remain constant throughout the planning period.

STEP 6: 1988 Base Service Population

The population figures obtained in Steps 3, 4 and 5 are added to obtain the 1988 Base Service Population.

STEP 7: 1986-1988 Base Average Day Demand (ADD)

The 1986-1988 Base ADD is obtained by averaging a water supply system's 1986, 1987 and 1988 ADD. Net water consumption figures were obtained from the Division of Water Supply (DEP) "Water Supply Statistics" forms. These forms, submitted to DEP by each water supply agency in January report the total water pumped by the system for the previous calendar year. Net water consumption is the water pumped from the system's own sources plus water purchased from other systems minus water sold to other systems.

The ADD, in millions of gallons per day (mgd), represents the total average daily water consumption. This includes domestic, commercial, institutional, industrial, agricultural, and municipal uses, as well as unaccounted for water use. Unaccounted for water includes unmetered water, leakage, fire hydrant use, street washing, and distribution system flushing.

STEP 8: 1986-1988 GPCD

Gallons per capita day (GPCD) for a community is obtained by dividing the base ADD figure obtained in Step 7 by the 1988 Base Service Population obtained in Step 6.

STEP 9: 2020 Population Projections

Population projections are obtained from MISER, local governments, and for Bellingham only, MAPC. The population projections were based on state and regional growth patterns. MAPC'S projections are prepared in five-year increments to 2010. Population projections for the year 2020 were derived from the projected growth rate between 2000 and 2010, extended to 2020. The MAPC publication, "The Population and Employment Outlook for the Metropolitan Boston Area, A Preliminary Report and Methodology", (March, 1988), explains the agency's projection methodology and contains detailed explanatory charts and tables.

STEP 10: 2020 Minimum Service Population

This figure reflects the service population that would occur in 2020 assuming no growth in the area served and no increase in the seasonal population. This figure is obtained by multiplying the 1988 percent service population by the 2020 population projection and adding seasonal and out-of-town customers.

STEP 11: 2020 Base Average Day Demand

The 2020 base average day demand is the estimated minimum average day demand needed by the community's public water supply system. This figure assumes no change in the present water use pattern except for the projected community population growth or decline and is obtained by multiplying the 2020 minimum service population by the base GPCD.

STEP 12: 2020 Increase in Percent Service Population

It is assumed that in communities where the service population is less than 100 percent of its census population, the percentage of people served will increase during the planning period. The estimates of service area growth are developed from discussions with local water supply system managers and from historical experience with service area development in response to, or in anticipation of, population growth within a community.

For planning purposes, it is assumed that:

> Those communities with a 100 percent service population in 1988 will remain at 100 percent through the planning period.
>
> Those communities with a 1988 service population of 90 percent or more will increase 5 percent per decade with all reaching 100 percent by 2010. It is assumed that the 1988 service population will remain the same until 1990.
>
> Those communities with a service population of less than 90 percent are adjusted individually, based upon estimates of service area growth to 1990, as reported by the water system managers, and then increased by 10 percent per decade until 2020.

In some cases, percent increase is adjusted at a different rate, as suggested by interviews with water supervisors and other local sources.

STEP 13: 2020 Adjusted Service Population

This figure represents the estimated service population if the anticipated service area increase occurs. The figure is obtained by multiplying the 2020 percent service population by the 2020 population projection and adding the 1986 seasonal population factor and any out-of-town customers.

STEP 14: 2020 GPCD

It is assumed that GPCD will begin to rise slightly due to future residential growth, and commercial and industrial expansion increase. This assumes minimum water conservation. These factors will cause GPCD to rise incrementally from the year 1990 to 2020, resulting in an increase of 15 percent (5 percent per decade) by 2020 for each community. Therefore, the 2020 gpcd figure is obtained by multiplying the 1986-1988 GPCD by 1.15 (15 percent). This assumption produces conservative figures for water demands. In Volume III of the river basin study, each community's activities in water conservation will be considered, permitting a more refined projection.

STEP 15: Significant Changes Anticipated in Water Use

This figure is a one-time adjustment to the estimated 2020 water demand resulting from extraordinary changes to a community's water needs. Examples of changes are the construction of a wastewater recovery plant or a fish processing plant, or the permanent closing of an industry with major water use.

STEP 16: Adjusted 2020 ADD

This figure is the 2020 ADD adjusted to reflect the increased water demand resulting from service area expansion, local refinements to population projections, an increase in GPCD by 15 percent from 1990 to 2020, and any significant changes in water use. It is obtained by multiplying the 2020 GPCD by the 2020 adjusted service population and then adding or subtracting any significant changes to or from the 2020 ADD.

STEP 17: 1986-1988 Maximum Day Demand

The 1986-1988 Maximum Day Demand (MDD) is obtained by averaging the maximum day demand reported by the water supply system on the DEP "Water Supply Statistics" forms for the years 1986, 1987 and 1988. MDD is reported in millions of gallons per day (mgd) and represents an actual maximum amount of water used for one day in a given year for the water system.

STEP 18: 1986-1988 Base MDD to ADD Ratio

The MDD for each year (1986-1988) is divided by the ADD for that same year to obtain a ratio. These three ratios are averaged to obtain a base MDD/ADD ratio. For planning purposes, it is assumed that this ratio will remain constant through 2020.

STEP 19: 2020 Maximum Day Demand

This figure is obtained by multiplying the adjusted 2020 ADD by the 1986-1988 MDD/ADD ratio.

APPENDIX 3A

Process Used to Identify and Locate Massachusetts Public Water Supply Sources.

This appendix is compiled from data obtained from the local public water systems during the inventory and analysis stage of the planning process. It should be read in conjunction with Appendix 3B, a map of the water supply sources, and 3C, a table listing water supply sites and locations. The following information is provided to clarify the data on the map and table.

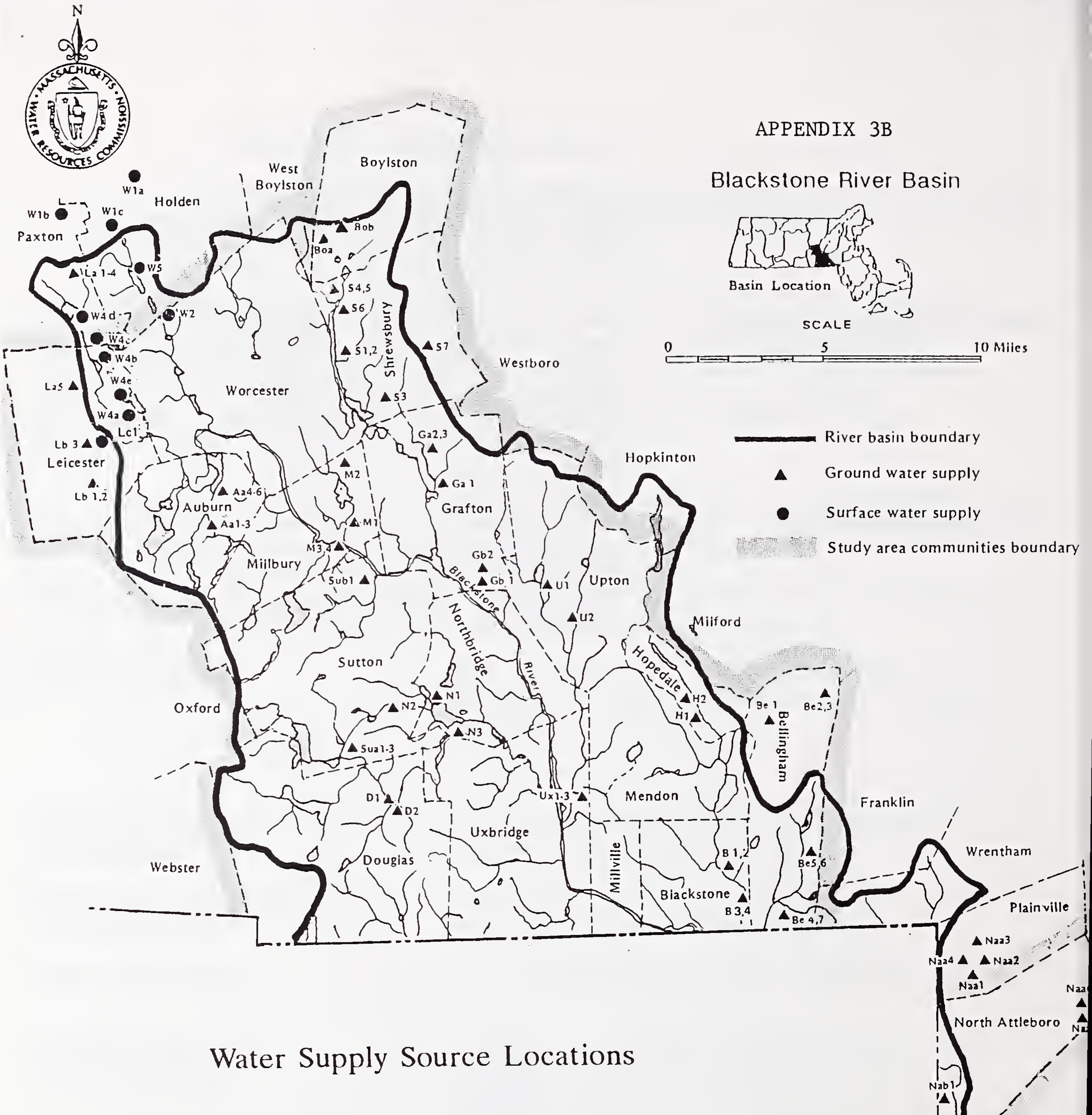
The water supply source identifying symbols on the map show the approximate location of the sources. Where several sources are in close proximity, the symbols are grouped on the map.

Water Supply Agency	The name of the water supply agency which operates the source.
Name of Source	The name of the individual water source as given by the water supply agency.
Basin Location of The Source	The river basin in which the water supply source is located.
Community Location of The Source	The city or town in which the water supply source is located.
Type of Source	GW - Ground water, SW - Surface water
Pumping Capacity of The Source	Pumping capacity of a source is the maximum amount of water that can be pumped into the distribution system and/or from river to reservoir or reservoir to reservoir.
1988 Average Day Demand of Source	This number is the total water pumped from a source in calendar year 1988, divided by 366 days.
DEP Map Number	The DEP number identifies the water source according to a system designed by the Department of Environmental Protection. The numbers convey, in standard sequence, the town in which the supply is located (which is not necessarily the town it serves), the

site number, and its status.

DEP Source Code Number	The DEP number assigned to each source which identifies the town which uses the source and whether it is a surface or ground water source.
Latitude and Longitude	The latitude and longitude numbers are given for each individual source, except when two or more sources are in very close proximity. By using these numbers, sources can be located on USGS 7.5 minute series topographic maps.
DWR Source Number	This number is assigned by DWR and corresponds to the source listed on the Water Supply Source Map in Appendix 3B and on the source listing on each Town Summary Sheet.

APPENDIX 3B



Water Supply Source Locations

Aa	Auburn Water District
Be	Bellingham Water Department
B	Blackstone Water Department
Boa	Morningdale Water Distict (Boylston)
Bob	Boylston Water District (Boylston)
D	Douglas Water District
Ga	Grafton Water District
Gb	South Grafton Water District
H	Hopedale Water Department
La	Leicester Water District
Lb	Hillcrest Water District (Leicester)
Lc	Cherry Valley & Rochedale Water District (Leicester)
M	Mass. American Water Company (Millbury)
Naa	North Attleboro Water Department
Nab	Kings Grant Estates (No, Attleboro)
N	Whitinsville Water Company (Northbridge)
S	Shrewsbury Water Department
Sua	Manchaug Water District (Sutton)
Sub	Wilkinsonville Water District (Sutton)
U	Upton Water & Sewer Department
Ux	Uxbridge Water Department
W	Worcester Water Department

DEM/Division of Water Resources

APPENDIX 3-C

1988 PUBLIC WATER SUPPLY SOURCES

COMMUNITY WATER SUPPLY AGENCY	NAME OF SOURCE	BASIN LOCATION OF SOURCE	COMMUNITY LOCATION OF SOURCE	TYPE OF SOURCE	PUMPING CAPACITY OF SOURCE (mgd)	1988 ADD OF SOURCE (mgd)	DEP MAP NUMBER	DEP SOURCE CODE NUMBER	LATITUDE \ LONGITUDE OF SOURCE	DWR MAP SYMBOL OF SOURCE
Auburn										
Auburn Water District	Church St., #1	Blackstone	Auburn	GW	0.65	0.35	21A-017-303A	017-01G	42 11 42/71 50 32	Aa1
	Church St., #2	Blackstone	Auburn	GW	0.29	----	21A-017-304A	017-02G	42 11 42/71 50 32	Aa2
	Church St., #3	Blackstone	Auburn	GW	0.27	0.15	21A-017-305A	017-03G	42 11 42/71 50 32	Aa3
	Walsh Ave., #4	Blackstone	Auburn	GW	0.48	0.24	21A-017-301A	017-04G	42 12 50/71 49 52	Aa4
	Walsh Ave., #5	Blackstone	Auburn	GW	0.50	0.32	21A-017-300A	017-05G	42 12 56/71 49 48	Aa5
	Southbridge, #6	Blackstone	Auburn	GW	0.40	0.17	21A-017-302A	017-06G	42 12 30/71 49 56	Aa6
					====	====				
					2.59	1.23				
Woodland Water Dist.	City of Worcester	Blackstone	Worcester	SW	----	0.03				Ab
Elmhill Water Dist.	City of Worcester	Blackstone	Worcester	SW	----	0.07				Ac
						========				
						1.33				
Bellingham										
Bellingham Water Department	Wrentham Rd., #4	Blackstone	Bellingham	GW	0.52	0.51	41A-025-309A	025-04G	42 01 45/71 28 46	BE4
	Cross St., #1	Blackstone	Bellingham	GW	0.52	0.30	41A-025-308A	025-01G	42 03 19/71 28 03	BE5
	Cross St., #2	Blackstone	Bellingham	GW	0.36	0.11	41A-025-207A	025-02G	42 03 17/71 28 00	BE6
	Wrentham Rd., #3	Blackstone	Bellingham	GW	0.65	0.09	41A-025-310A	025-03G	42 01 43/71 28 54	BE7
	Taunton St., #5	Charles	Bellingham	GW	0.29	0.30	41A-025-304A	025-05G	42 06 09/71 29 04	BE1
	Maple St., #8	Charles	Bellingham	GW	0.90	0.17	41A-025-200A	025-06G	42 07 26/71 27 48	BE2
	Maple St., #7	Charles	Bellingham	GW	0.33	----	41A-025-201A	025-08G	42 07 24/71 27 58	BE3
					====	========				
					3.57	1.48				

COMMUNITY WATER SUPPLY AGENCY	NAME OF SOURCE	BASIN LOCATION OF SOURCE	COMMUNITY LOCATION OF SOURCE	TYPE OF SOURCE	PUMPING CAPACITY OF SOURCE (mgd)	1988 ADD OF SOURCE (mgd)	DEP MAP NUMBER	DEP SOURCE CODE NUMBER	LATITUDE \ LONGITUDE OF SOURCE	DWR MAP SYMBOL OF SOURCE
Blackstone										
Blackstone Water	Summer St., #1	Blackstone	Blackstone	GW	0.27	0.20	21A-032-302A	032-01G	42 02 25/71 31 00	B1
Department	Summer St., #2	Blackstone	Blackstone	GW	0.17	---	21A-032-303C	032-02G	42 02 23/71 30 30	B2
	Elm St., #4	Blackstone	Blackstone	GW	0.29	0.14	21A-032-300A	032-04G	42 02 09/71 30 30	B3
	Elm St., #5	Blackstone	Blackstone	GW	0.43	0.26	21A-032-300A	032-05G	42 02 12/71 30 21	B4
					====	====				
					1.72	0.60				
Boylston						(wells #1 & #2 metered together)				
Boylston Water	Well #1	Blackstone	Boylston	GW	0.86		21A-039-302A	039-01G	42 20 17/71 44 46	BOb1
District	Well #2	Blackstone	Boylston	GW	0.30	0.25	21A-039-301A	039-02G	42 20 16/71 44 44	BOb2
					====	========				
					1.16	0.25				
Morningdale						(wells #1 & #2 metered together)				
Water District	Well #1	Blackstone	Boylston	GW	0.84		21A-039-304A	039-01G	42 20 17/71 44 50	BOa1
	Well #2	Blackstone	Boylston	GW	0.33	0.21	21A-039-203A	039-02G	42 20 13/71 44 45	BOa2
					====	====				
					1.17	0.21				
						=====				
						0.46				
Douglas										
Douglas Water	Well #1	Blackstone	Douglas	GW	0.43	0.10	21A-077-300A	077-02G	42 04 21/71 43 16	D1
Department	Wellfield #2	Blackstone	Douglas	GW	0.24	0.14	21A-077-301A	077-01G	42 04 10/71 43 17	D2
					====	========				
					0.67	0.24				

COMMUNITY WATER SUPPLY AGENCY	NAME OF SOURCE	BASIN LOCATION OF SOURCE	COMMUNITY LOCATION OF SOURCE	TYPE OF SOURCE	PUMPING CAPACITY OF SOURCE (mgd)	1988 ADD OF SOURCE (mgd)	DEP MAP NUMBER	DEP SOURCE CODE NUMBER	LATITUDE \ LONGITUDE OF SOURCE	DWR MAP SYMBOL OF SOURCE
Grafton										
Grafton Water District	Worcester St.	Blackstone	Grafton	GW	1.00	0.68	21A-110-302A	110-02G	42 13 09/71 41 35	Ga1
	East St., #2	Blackstone	Grafton	GW	0.61	0.08	21A-110-300A	110-03G	42 14 47/71 42 09	Ga2
	East St., #3	Blackstone	Grafton	GW	1.00	0.00	21A-110-301A	110-04G	42 14 51/71 42 09	Ga3
					====	====				
					2.61	0.76				
So. Grafton Water District	Providence Rd.	Blackstone	Grafton	GW	0.36	0.05	21A-110-305A	110-01G	42 10 08/71 40 19	Gb1
	Ferry St., #1	Blackstone	Grafton	GW	0.35	0.13	21A-110-304A	110-02G	42 10 27/71 40 14	Gb2
					====	====				
					0.71	0.18				
						=====				
						0.94				
Hopedale										
Hopedale Water Department	Mill St. Wellfield	Blackstone	Hopedale	GW	0.40	0.29	21A-138-301A	138-01G	42 06 36/71 31 34	H1
	Greene St. Wells	Blackstone	Hopedale	GW	0.10	0.04	21A-138-300C	138-02G	42 07 04/71 31 59	H2
	Milford Water Co.	Charles	Milford	-		{0.14}				
					====	====				
					0.50	0.33				
Leicester					Paxton #1-#3 and Jim Dandy metered together					
Leicester Water Supply District	Paxton Well #1	Blackstone	Paxton	GW	0.07		21A-228-301A	151-03G	42 18 32/71 54 48	La1
	Paxton Well #2	Blackstone	Paxton	GW	0.12		21A-228-302A	151-01G	42 18 24/71 54 47	La2
	Paxton Well #3	Blackstone	Paxton	GW	0.17		21A-228-304A	151-06G	42 18 29/71 54 40	La3
	Jim Dandy Well	Blackstone	Paxton	GW	0.10	0.17	21A-228-300A	151-04G	42 18 44/71 54 48	La4
	Whitemore Well #4	French	Leicester	GW	0.07	0.03	21A-151-303A	151-05G	42 15 26/71 54 37	La5
					====	====				
					0.53	0.20				
Cherry Valley and Rochdale Water District	Henshaw Pond	French	Leicester	SW	0.45	0.26	NA	151A01F	NA	Lc1
						====				
						0.26				

COMMUNITY WATER SUPPLY AGENCY	NAME OF SOURCE	BASIN LOCATION OF SOURCE	COMMUNITY LOCATION OF SOURCE	TYPE OF SOURCE	PUMPING CAPACITY OF SOURCE (mgd)	1988 ADD OF SOURCE (mgd)	DEP MAP NUMBER	DEP SOURCE CODE NUMBER	LATITUDE \ LONGITUDE OF SOURCE	DWR MAP SYMBOL OF SOURCE
Hillcrest Water	Well #1	French	Leicester	GW	0.09	standby	NA	151B01D	NA	Lb1
District	Well #2	French	Leicester	GW	0.14	0.07	NA	151B01G	NA	Lb2
	Well #3	French	Leicester	GW	0.09	standby	NA	151B02G	NA	Lb3
					====	====				
					0.32	0.07				
					======	======				
					1.55	0.53				
Mendon (portion of town										
supplied by Milford	Milford Water Co.	Charles	Milford							
Water Company)										
Millbury										
Mass. American Water	Millbury Ave.	Blackstone	Millbury	GW	1.40	0.48	21A-186-202A	186-01G	42 12 02/71 45 25	Ml1
Company	Oak Pond	Blackstone	Millbury	GW	1.01	0.51	21A-186-300A	186-02G	42 13 26/71 45 16	Ml2
	North Main #1	Blackstone	Millbury	GW	0.86	0.40	21A-186-303A	186-03G	42 11 59/71 46 22	Ml3
	North Main #2	Blackstone	Millbury	GW	0.50	0.28	21A-186-304A	186-04G	42 11 52/71 46 16	Ml4
					====	====				
					3.77	1.67				
Millville	NO CENTRAL SUPPLY									
North Attleboro										
No. Attleboro Water	Plainville #1	Ten Mile	Plainville	GW			41A-238-302A	211-02G	42 00 23/71 20 23	Naa1
Department	Plainville #2	Ten Mile	Plainville	GW	====	====	41A-238-307A	211-03G	42 00 32/71 20 34	Naa2
	Plainville #3	Ten Mile	Plainville	GW	1.34	0.88	41A-238-208A	211-04G	42 00 43/71 20 44	Naa3
	Plainville #4/Whit.	Ten Mile	Plainville	GW	1.25	0.61	---	211-07G	42 00 21/71 20 24	Naa4
	Kelly #1	Ten Mile	No. Attleboro	GW	0.67	0.38	41A-211-302A	211-05G	41 58 44/71 17 16	Naa5
	Kelly #2	Ten Mile	No. Attleboro	GW	0.67	0.36	41A-211-301A	211-06G	41 58 53/71 17 15	Naa6
	Adamsdale	Blackstone	No. Attleboro	GW	0.67	0.53	21A-211-304A	211-08G	41 55 24/71 22 30	Naa7
					====	====				
					4.60	2.76				

COMMUNITY WATER SUPPLY AGENCY	NAME OF SOURCE	BASIN LOCATION OF SOURCE	COMMUNITY LOCATION OF SOURCE	TYPE OF SOURCE	PUMPING CAPACITY OF SOURCE (mgd)	1988 ADD OF SOURCE (mgd)	DEP MAP NUMBER	DEP SOURCE CODE NUMBER	LATITUDE \ LONGITUDE OF SOURCE	DWR MAP SYMBOL OF SOURCE
King's Grant Estates Water Co.	Longview Drive Well	Blackstone	No. Attleboro	GW	0.40	0.08	21A-211-303A	211A01G	41 55 55/71 22 20	Nab1
					====	=====				
					5.00	2.84				
Whitinsville Water Company	Whiten Wellfield	Blackstone	Northbridge	GW	2.00	0.60	21A-216-301A	216-02G	42 07 00/71 41 30	N1
	Sutton Wellfield	Blackstone	Sutton	GW	1.50	0.53	21A-290-300A	290-03G	42 07 00/71 42 53	N2
	Gravel Pack Well	Blackstone	Northbridge	GW	0.50	0.00	21A-216-302A	216-03G	42 06 28/71 41 11	N3
					====	====				
					4.88	1.13				
Northbridge Water Department	Whitinsville Water Co.	Blackstone		GW		0.36				
Shrewsbury										
Shrewsbury Water Department	Lambert #1	Blackstone	Shrewsbury	GW	0.76	0.34	21A-271-302A	271-04G	42 17 30/71 45 12	S1
	Lambert #2	Blackstone	Shrewsbury	GW	0.47	0.05	21A-271-303A	271-05G	42 17 33/71 45 10	S2
	Oak St. #3	Blackstone	Shrewsbury	GW	0.40	0	21A-271-203A	271-03G	42 16 00/71 44 55	S3
	Sewell St. #4	Blackstone	Shrewsbury	GW	1.14	0.86	NA	271-02G	42 18 26/71 45 07	S4
	Sewell St. #5	Blackstone	Shrewsbury	GW	0.72	0.27	21A-271-301A	271-06G	42 18 28/71 45 07	S5
	Home Farm #6	Blackstone	Shrewsbury	GW	2.88	1.50	21A-271-300A	271-07G	42 17 58/71 45 17	S6
	South St. #7	Concord	Shrewsbury	GW	0.32	0.17	21A-271-204A	271-01G	42 17 01/71 42 12	S7
					====	====				
					6.69	3.19				
Sutton										
Wilkinsonville Water District	Hatchery Road Well	Blackstone	Sutton	GW	0.20	0.08	21A-290-300A	290-03G	42 10 19/71 44 07	Sub1
Manchaug Water District	Manchaug #1	Blackstone	Sutton	GW			21A-290-301A	NA	42 05 57/71 45 00	Sua1
	Manchaug #2	Blackstone	Sutton	GW			21A-290-302A	NA	42 05 55/71 45 00	Sua2
	Manchaug #3	Blackstone	Sutton	GW	====	====	21A-290-303A	NA	42 05 53/71 45 00	Sua3
					0.13	0.03				
					=====	====				
					0.33	0.11				

WATER SUPPLY AGENCY	NAME OF SOURCE	BASIN LOCATION OF SOURCE	COMMUNITY LOCATION OF SOURCE	TYPE OF SOURCE	PUMPING CAPACITY OF SOURCE (mgd)	1988 ADD OF SOURCE (mgd)	DEP MAP NUMBER	DEP SOURCE CODE NUMBER	LATITUDE \ LONGITUDE OF SOURCE	DWR MAP SYMBOL OF SOURCE
Upton										
Upton Water	Glen Ave.	Blackstone	Upton	GW	0.40	0.12	21A-303-300A	303-01G	42 10 00/71 37 42	U1
Department	West River	Blackstone	Upton	GW	0.80	0.15	21A-303-301A	303-02G	42 09 25/71 36 33	U2
					====	========				
					1.20	0.27				
Uxbridge										
Uxbridge Water	Blackstone St. #1	Blackstone	Uxbridge	GW		0.40	21A-304-300A	304-01G	42 04 14/71 36 27	Ux1
Department	Blackstone St. #2	Blackstone	Uxbridge	GW		0.34	21A-304-301A	304-02G	42 04 39/71 36 25	Ux2
	Blackstone St. #3	Blackstone	Uxbridge	GW		0.01	21A-304-302A	304-03G	42 04 37/71 36 28	Ux3
					====	====				
					1.00	0.75				
Worcester										
Worcester Water	Quinapoxet Reservoir	Nashua	Holden	SW			21A-134-309B	348-05S	42 23 06/71 53 15	W1a
Department	Pine Hill Reservoir	Nashua	Holden	SW		====	21A-134-304B	348-04S	42 21 00/71 54 21	W1b
	Kendall Reservoir	Nashua	Holden	SW		12.97	21A-134-303B	348-03S	42 19 42/71 53 00	W1c
	Holden Reservoir #2	Blackstone	Holden	SW			21A-134-307B	348-02S	42 18 36/71 52 40	W2
	Holden Reservoir #1	Blackstone	Holden	SW		10.71	21A-134-305B	348-06S	42 18 21/71 52 20	W5
	Kettlebrook #1	Blackstone	Leicester	SW			21A-151-304B	348-07S	42 15 25/71 53 28	W4a
	Kettlebrook #2	Blackstone	Leicester	SW			21A-151-301B	348-08S	42 16 18/71 54 03	W4b
	Kettlebrook #3	Blackstone	Paxton	SW			21A-228-306B	NA	42 16 55/71 54 32	W4c
	Kettlebrook #4	Blackstone	Paxton	SW			21A-228-305B	NA	42 17 50/71 54 45	W4d
	Lyndebrook Reservoir	Blackstone	Leicester	SW		3.50	21A-151-305B	348-01S	42 15 49/71 54 33	W4e
	Shrewsbury Well	Blackstone	Shrewsbury	GW	0.79	=====	21A-348-301A	348-01G	42 18 05/71 45 33	W6

APPENDIX 4

The Water Management Act

The Massachusetts Water Management Act (WMA) (MGL Ch 21G) and regulations (310 CMR 36.00) became effective in March, 1986. The act calls for comprehensive management, by river basin, of the Commonwealth's surface and ground water resources.

The Department of Environmental Protection (DEP) is authorized to regulate and monitor significant water withdrawals from Massachusetts ground and surface water supplies and is given greater authority to manage water supply emergencies. Implementation of the act is taking place in two phases: **registration** of the volume of withdrawals from existing sources, and **permitting** of the volume of water withdrawals from new sources.

Registered volumes refer to the average amount of water withdrawn from a community's sources between 1981 and 1985. All those who withdrew more than an average of 100,000 gallons per day during the 1981-1985 period were required to register those withdrawals by January 4, 1988.

Permitted volumes reflect withdrawals from new sources over 100,000 gallons per day or withdrawals from registered sources above the volumes previously registered. Permits will be issued for 5 to 20 year periods with most permits issued for a 20-year period.

Registration and permitting are being carried out by river basin (see attached schedule). Public water suppliers with sources in more than one basin will register their sources in each basin and will apply for permits as the basins are scheduled for permitting. After all permit applications have been submitted for a basin, applications for additional withdrawals can be submitted on the filing date for that basin in subsequent years.

The current and projected water demands for each community shown in this report may differ from the volume registered and the volume permitted for each community. The demand figure prepared by the Office of Water Resources for each community is the amount of water used by a community, derived from the water supply data available for the latest three years. This figure may include water purchased from other communities, but does not include water withdrawals sold to other communities.

Historic water use data in Table 2 shows the basin water use by community for the period 1980-1988.

WATER MANAGEMENT ACT PERMIT APPLICATION SCHEDULE

Water Source	Effective Date: First Filing Date	Completion Date	Subsequent Filing Date	Subsequent Completion
Hudson River Basin	August 31, 1988	February 28, 1989	August 31, each year	February 28, each year
Blackstone, Charles Basins	February 28, 1989	August 31, 1989	February 28, each year	August 31, each year
Ipswich, North Coastal Basins	August 31, 1989	February 28, 1990	August 31, each year	February 28, each year
Boston Harbor, Taunton Basins	February 28, 1990	August 31, 1990	February 28, each year	August 31, each year
South Coastal Basin	August 31, 1990	February 28, 1991	August 31, each year	February 28, each year
Cape Cod Basin	November 30, 1990	May 31, 1991	November 30, each year	May 31, each year
Islands Basin	February 28, 1991	August 31, 1991	February 28, each year	August 31, each year
Buzzards Bay Basin	May 31, 1991	November 30, 1991	May 31, each year	November 30, each year
Concord Basin	August 31, 1991	February 28, 1992	August 31, each year	February 28, each year
Ten Mile Basin	November 30, 1991	May 31, 1992	November 30, each year	May 31, each year
Deerfield Basin	February 28, 1992	August 31, 1992	February 28, each year	August 31, each year
Housatonic Basin	May 31, 1992	November 30, 1992	May 31, each year	November 30, each year
Farmington Basin	August 31, 1992	February 28, 1993	August 31, each year	February 28, each year
Westfield Basin	November 30, 1992	May 31, 1993	November 30, each year	May 31, each year
Millers Basin	February 28, 1993	August 31, 1993	February 28, each year	August 31, each year
Connecticut Basin	May 31, 1993	November 30, 1993	May 31, each year	November 30, each year
Quinnebaug Basin	August 31 1993	February 28, 1994	August 31, each year	February 28, each year
Chicopee Basin	November 30, 1993	May 31, 1994	November 30, each year	May 31, each year
Nashua Basin	February 28, 1994	August 31, 1994	February 28, each year	August 31, each year
French Basin	May 31, 1994	November 30, 1994	May 31, each year	November 30, each year
Shawsheen Basin	August 31, 1994	February 28, 1995	August 31, each year	February 28, each year
Merrimack basin	November 30 1994	May 31 1995	November 30, each year	May 31, each year
Parker Basin	February 28, 1995	August 31, 1995	February 28, each year	August 31, each year
Narragansett Basin	May 31, 1995	November 30, 1995	May 31, each year	November 30, each year

APPENDIX 5A

Self-Supplied Residential Water Use

On-site self-supplied residential wells account for a small portion of the domestic water supply needs of the people living in the Blackstone River basin. All eighteen communities have areas that are self-supplied. In 1988, nine percent (29,644) of the people living in the basin obtained their water supply from on-site residential wells. The 1988 estimated average day demand from these wells was approximately 2.09 mgd, or five percent of the 1988 ADD of the public water supply systems in the basin. (See attached table)

Source of Data

The following methodology was used by OWR to estimate the amount of water used for domestic purposes by residents with individual on-site wells within the hydrological boundaries of the Blackstone River Basin.

STEP 1: Approximate the number of self-supplied residents within the study area communities. Each water agency manager reported service population as a percent of town population in the 1986 Water Resources Management Plan -- Phase II questionnaire. The self-supplied population would, therefore, be the total service population subtracted from the community's 1986 census population. For example, 95 percent of the population of Shrewsbury (21,432 out of 22,560) is served by the Shrewsbury Water Department. The remaining five percent (1,128) are considered to be self-supplied.

STEP 2: Determine self-supplied water use. The 1986 self-supplied residential water use was estimated by multiplying the community's self-supplied population by 79 gallons per capita per day (GPCD). The GPCD factor was taken from the "Estimated Use of Water in the U.S. in 1980" prepared by the U.S. Geologic Survey. The 79 GPCD was used to estimate rural self-supplied use and was verified for Massachusetts in a study of water supply systems in the Parker River basin.

STEP 3: Determine the amount of self-supplied residential water withdrawn from the Blackstone River Basin. For those communities whose land area lies entirely within the Blackstone River basin boundaries, it can be assumed that all self-supplied water is withdrawn from the basin. However, this assumption does not hold for communities lying partially in the basin. In these instances, the water withdrawn from the basin was calculated based on the percentage of its land area within the Blackstone River basin. For example, Shrewsbury has land area within two river basins, the Blackstone and the Concord. Of the town's total 21.7 square miles, 65 percent, or 14 square miles, lies within the Blackstone River basin. Assuming self-supplied users are distributed proportionately throughout the town, the water withdrawn from the Blackstone basin for self-supplied residential use in Shrewsbury can be calculated by multiplying 65 percent by the total self-supplied water use obtained in Step 2:

65% x .09 mgd = .06 mgd from the Blackstone River basin.

APPENDIX 5A
BLACKSTONE RIVER BASIN STUDY AREA
SELF-SUPPLIED RESIDENTIAL WATER USE (1988)

Community	1988 Self-supplied Population	Water Use at 79 Gallons per Capita Day	Percent of Town Area within Blackstone Basin	Estimated Self-Supplied Water Use in Blackstone Basin(mgd)
Auburn	2,625	0.21	93	0.20
Bellingham	427	0.03	48	0.01
Blackstone	498	0.04	100	0.04
Boylston	494	0.04	20	0.01
Douglas	2,111	0.17	86	0.14
Grafton	2,131	0.17	93	0.16
Hopedale	750	0.06	81	0.05
Leicester	871	0.07	33	0.02
Mendon	3,490	0.28	98	0.27
Millbury	1,954	0.15	99	0.15
Millville	2,010	0.16	100	0.16
North Attleboro	704	0.06	21	0.01
Northbridge	1,990	0.16	100	0.16
Shrewsbury	1,128	0.09	65	0.06
Sutton	5,190	0.41	98	0.40
Upton	1,921	0.15	96	0.14
Uxbridge	1,350	0.11	100	0.11
Worcester	0	0.00	99	0.00
Total:	29,644	2.36	-	2.09 mgd

APPENDIX 5B

Self-Supplied Non-Residential Water Use 1981 to 1985 Estimated Average

On-site water systems furnish a significant amount of water to agriculture, industry, and institutions in the Blackstone River basin. Under the Water Management Act of 1985 (WMA), registration of water withdrawals of 100,000 mgd or greater is required. This Appendix categorizes the different types of this use and lists the amounts of water (in mgd) registered under the Act by non-residential concerns. Self-supplied non-residential water users under 100,000 mgd, which were not registered under the Act, are not represented in this report.

Industrial and Commercial

Nine industrial and commercial users located in the Blackstone River basin registered under WMA. Estimated water use in this category is 6.56 mgd. The Wyman-Gordon Company is the largest water user with an average annual consumption of 3.38 mgd.

Agriculture

Two Blackstone River basin farms engaged in crop or livestock production registered under the WMA. Estimated water use for this category is 1.48 mgd/year.

Golf Courses

Five golf courses located in the Blackstone River basin registered under the WMA. Estimated water use for this category is 1.56 mgd/year.

APPENDIX 6

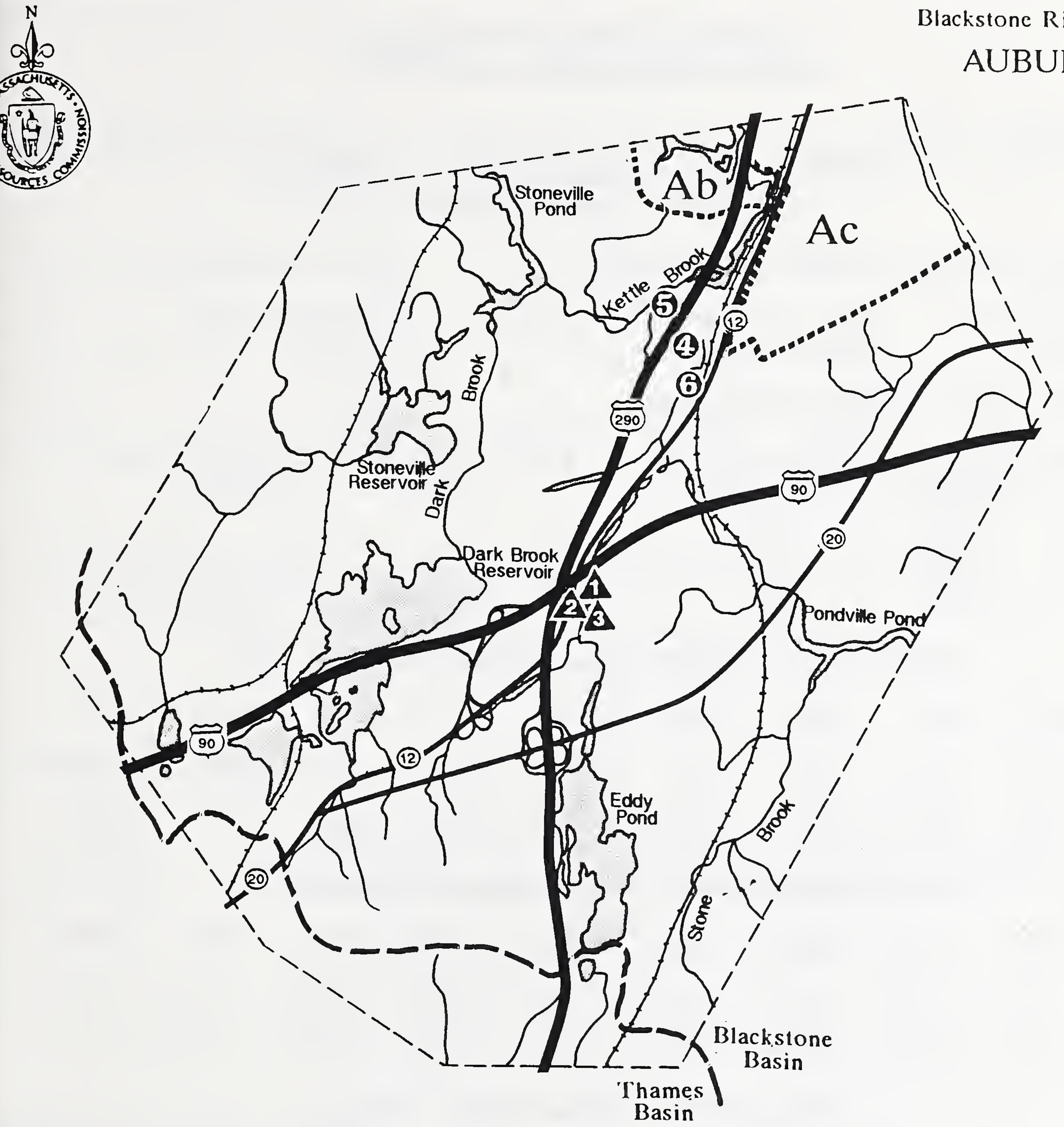
Community Water Supply Facts - Summary Sheets

Community Page

Auburn.. 63
Bellingham.. 67
Blackstone.. 71
Boylston.. 75
Douglas 79
Grafton... 83
Hopedale.. 87
Leicester... 91
Millbury.. 95
North Attleboro... 99
Northbridge... 103
Shrewsbury.. 107
Sutton 111
Upton... 115
Uxbridge.. 119
Worcester... 123

Blackstone River Basin

AUBURN



Auburn Water District	▲ Aa1	Church St., Well #1
	▲ Aa2	Church St., Well #2
	▲ Aa3	Church St., Well #3
	● Aa4	Walsh Ave., Well #4
	● Aa5	Walsh Ave., Well #5
	● Aa6	Southbridge, Well #6
Woodland Water District	Ab	City of Worcester
Elmhill Water District	Ac	City of Worcester

LEGEND

— — —	River basin boundary
- - - - -	Study communities boundary
▲	Ground water source
●	Surface water source

SCALE

0 ½ 1 2 Miles

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Auburn

Water Supply Agencies:
(1) Auburn Water District
(2) Woodland Water District
(3) Elmhill Water District

River Basin Acreage Distribution			Total Acreage
Blackstone:	9768	(93%)	10,516 acres
French:	748	(7%)	

CURRENT PUBLIC WATER SUPPLY USE

	Population On Public Supply		Population With On-Site Wells	
	Number	Percent	Number	Percent
(1)	9,477	65		
(2)	583	4		
(3)	1,895	13		
	11,955	82	2625	18

Average Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
(1)	1.02	1.04	1.07	1.04	1.09	1.16	1.24	1.24	1.24
(2)	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
(3)	0.06	0.07	0.06	0.08	0.06	0.06	0.06	0.07	0.07

Maximum Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
(1)	1.79	2.04	1.64	1.81	1.69	1.48	1.83	2.20	2.25
(2)	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
(3)	0.09	0.10	0.09	0.12	0.09	0.09	0.09	0.10	0.10

1988 Monthly Average Day Demand

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(1)	1.1	1.2	1.1	1.1	1.2	1.6	1.4	1.4	1.3	1.2	1.1	1.2
(2)	Not broken down by monthly consumption											
(3)	Not broken down by monthly consumption											

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):	Blackstone	French
Volume Discharged by On-Site Septic Systems:	0.10	0.03
Volume Discharged by Municipal Sewer System:	1.17	0.04

OFFICE OF WATER RESOURCES

WATER SUPPLY FACTS - SUMMARY

Community: Auburn

Water Supply Agencies:
(1) Auburn Water District
(2) Woodland Water District
(3) Elmhill Water District

POPULATION

1970 (U.S. Census)	1980 (U.S. Census)	1986 Census Estimate	1995 (Projected)	2000 (Projected)	2010 (Projected)	2020 (Projected)
		(1)	(2)	(3)	(3)	(3)
15,347	14,845	14,580	15,135	15,143	15,177	15,965

(1) 1986 census estimate prepared by U.S. Bureau of Census
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
14,580	16.43	887

PROJECTED WATER DEMAND

Average Day Demand (mgd)

	1986-88 Base ADD	1995	2000	2010	2020
(1)	1.24	1.42	1.61	1.79	2.07
(2)	0.03	0.03	0.03	0.03	0.04
(3)	0.07	0.07	0.08	0.08	0.08

Maximum Day Demand (mgd)

	1986-88 Base MDD	1995	2000	2010	2020
(1)	2.09	2.40	2.71	3.02	3.50
(2)	0.05	0.05	0.05	0.06	0.06
(3)	0.10	0.11	0.11	0.11	0.12

OFFICE OF WATER RESOURCES

WATER SUPPLY FACTS - SUMMARY

Community: Auburn

Water Supply Agencies:
(1) Auburn Water District
(2) Woodland Water District
(3) Elmhill Water District

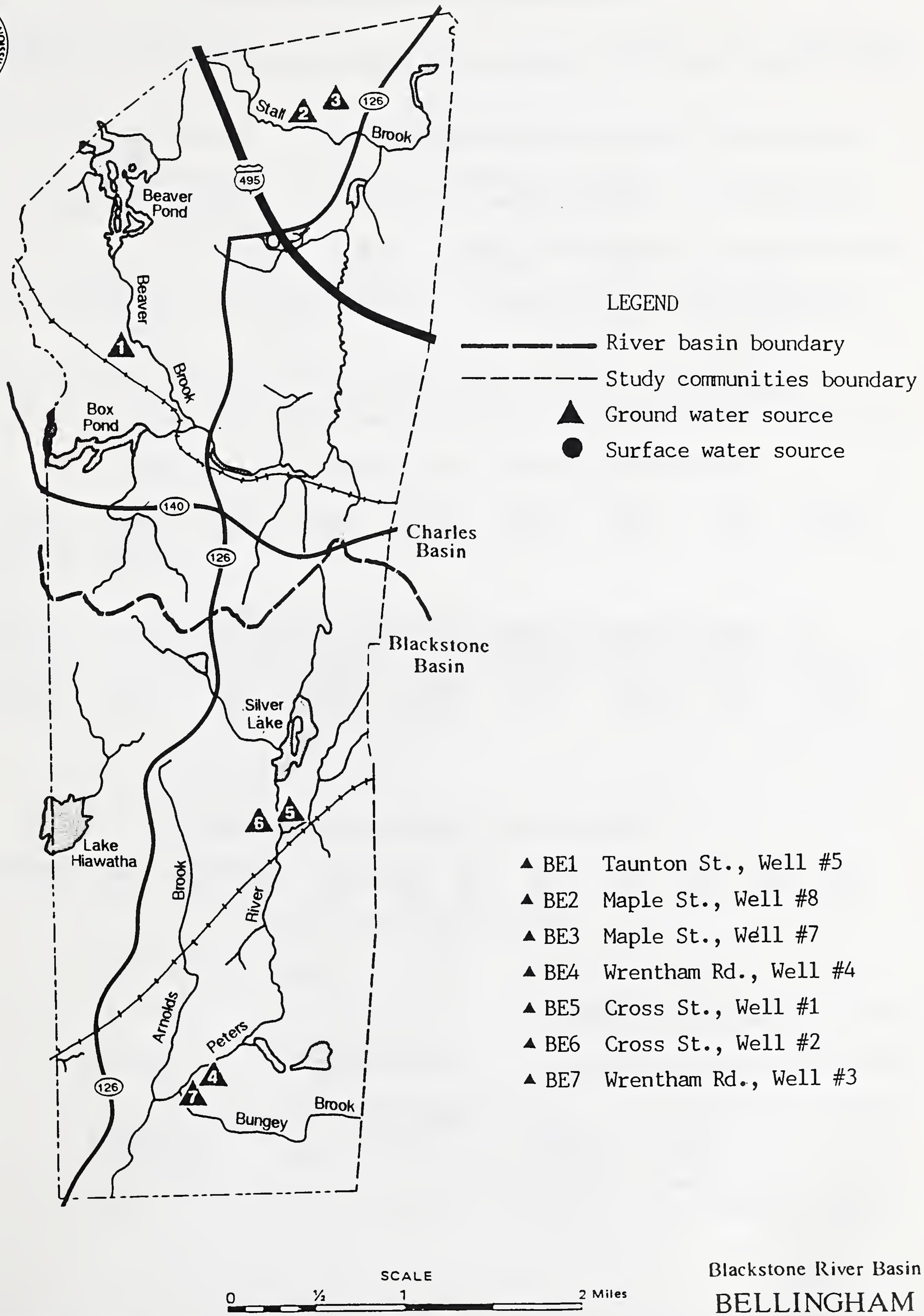
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity (MGD)	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Auburn Water District					
Church St. #1	Blackstone	0.65	0.35	Aa1	
Church St. #2	Blackstone	0.29	---	Aa2	Not used
Church St. #3	Blackstone	0.27	0.15	Aa3	
Walsh Ave. #4	Blackstone	0.48	0.24	Aa4	
Walsh Ave. #5	Blackstone	0.50	0.32	Aa5	
Southbridge #6	Blackstone	0.40	0.17	Aa6	
Woodland Water District					
City of Worcester	Blackstone		0.03		
Elmhill Water District					
City of Worcester	Blackstone		0.07		

Total ADD: 1.34 mgd

Total 1988 ADD on River Basin(s):

Blackstone 1.34 mgd



▲	BE1	Taunton St., Well #5
▲	BE2	Maple St., Well #8
▲	BE3	Maple St., Well #7
▲	BE4	Wrentham Rd., Well #4
▲	BE5	Cross St., Well #1
▲	BE6	Cross St., Well #2
▲	BE7	Wrentham Rd., Well #3

Blackstone River Basin
BELLINGHAM

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Bellingham
Water Supply Agency: Bellingham Water Department

River Basin Acreage Distribution			Total Acreage
Charles	6,302	(52%)	12,104 acres
Blackstone	5,802	(48%)	(18.91 sq. mi.)

CURRENT PUBLIC WATER SUPPLY USE

Population On Public Supply		Population With On-Site Wells	
Number	Percent	Number	Percent
13,816	97%	427	3%

(includes seasonal population factor of 38)

Average Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
1.03	1.08	1.16	1.13	1.15	1.26	1.27	1.35	1.48

Maximum Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
2.23	1.95	2.46	2.04	1.84	2.22	2.05	2.22	2.23

1988 Monthly Average Day Demand

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.3	1.3	1.4	1.3	1.5	1.9	1.5	1.7	1.6	1.6	1.4	1.3

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):	Blackstone	Charles
Volume Discharged by On-Site Septic Systems:	0.74	0.74
Volume Discharged by Municipal Sewer System:	0.00	0.00

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Bellingham
Water Supply Agency: Bellingham Water Department

POPULATION

1970 (U.S. Census)	1980 (U.S. Census)	1986 Census Estimate (1)	1995 (Projected) (2)	2000 (Projected) (2)	2010 (Projected) (2)	2020 (Projected) (3)
13,967	14,300	14,230	15,000	16,000	18,500	20,000

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the Metropolitan Area Planning Council (MAPC)
(3) OWR's extension of MAPC Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
14,230	18.91	753

PROJECTED WATER DEMAND

Average Day Demand (mgd)

1986-88 Base ADD	1995	2000	2010	2020
1.37	2.06	2.52	3.14	3.38

Maximum Day Demand (mgd)

1986-88 Base MDD	1995	2000	2010	2020
2.17	3.25	3.98	4.96	5.34

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Bellingham
Water Supply Agency: Bellingham Water Department

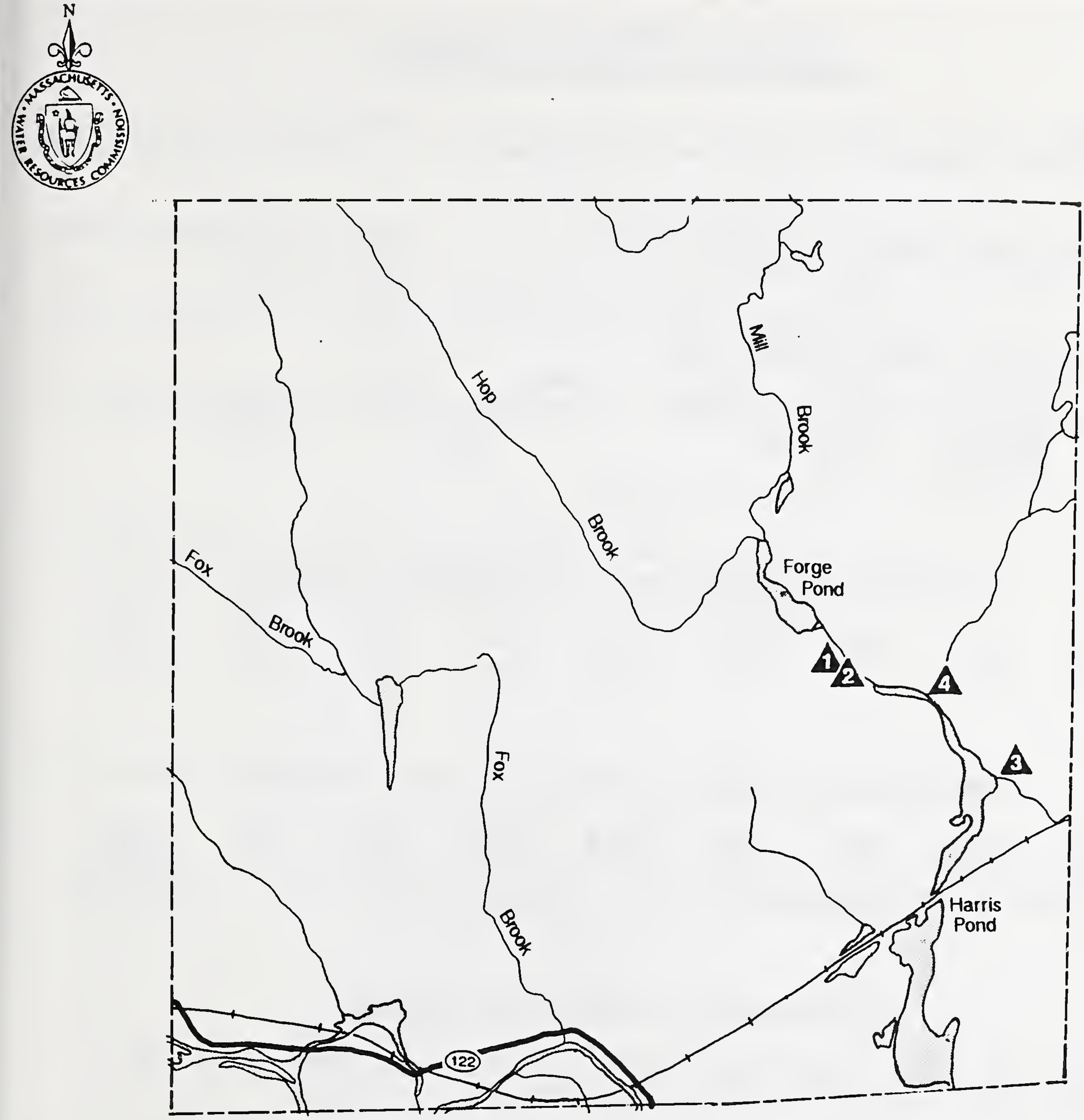
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Wrentham Rd. #4	Blackstone	0.52	0.51	BE-4	
Cross St. #1	Blackstone	0.52	0.30	BE-5	
Cross St. #2	Blackstone	0.36	0.11	BE-6	
Wrentham Rd. #3	Blackstone	0.65	0.09	BE-7	
Taunton St. #5	Charles	0.29	0.30	BE-1	
Maple St. #8	Charles	0.90	0.17	BE-2	
Maple St. #7	Charles	0.33	0.00	BE-3	Not used

Total ADD: 1.48 mgd

Total 1988 ADD on River Basin(s):

Blackstone	1.01 mgd
Charles	0.47 mgd



LEGEND

——— River basin boundary

- - - - Study communities boundary

▲ Ground water source

● Surface water source

▲ B1 Summer St., Well #1

▲ B2 Summer St., Well #2

▲ B3 Elm St., Well #4

▲ B4 Elm St., Well #5

SCALE

0 ½ 1 2 Miles

Blackstone River Basin

BLACKSTONE

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Blackstone
Water Supply Agency: Blackstone Water Dept.

River Basin Acreage Distribution	Total Acreage
Blackstone: 7302 (100%)	7302 acres (11.41 sq. mi)

CURRENT PUBLIC WATER SUPPLY USE

Population On Public Supply		Population With On-Site Wells	
Number	Percent	Number	Percent
6,670 (48 out of town customers)	93	498	7

Average Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
0.37	0.45	0.42	0.43	0.45	0.46	0.51	0.56	0.60

Maximum Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
0.63	0.90	0.73	0.70	0.93	0.94	0.89	1.67	1.10

1988 Monthly Average Day Demand

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.53	0.50	0.52	0.57	0.62	0.75	0.67	0.72	0.61	0.58	0.53	0.56

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):	Blackstone
Volume Discharged by On-Site Septic Systems:	0.58
Volume Discharged by Municipal Sewer System:	0.02

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Blackstone
Water Supply Agency: Blackstone Water Dept.

POPULATION

1970 (U.S. Census)	1980 (U.S. Census)	1989 Town Census (1)	1995 (Projected) (2)	2000 (Projected) (3)	2010 (Projected) (3)	2020 (Projected) (3)
6,566	6,570	7,767	8,746	9,181	9,411	9,910

(1) Prepared by the town of Blackstone
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
7,120	11.41	624

PROJECTED WATER DEMAND

Average Day Demand (mgd)

Base ADD*	1995	2000	2010	2020
0.63	0.77	0.88	0.96	1.06

* prepared from a estimate of 1989 data through September

Maximum Day Demand (mgd)

1986-88 Base MDD	1995	2000	2010	2020
1.22	1.69	1.92	2.10	2.31

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Blackstone
Water Supply Agency: Blackstone Water Department

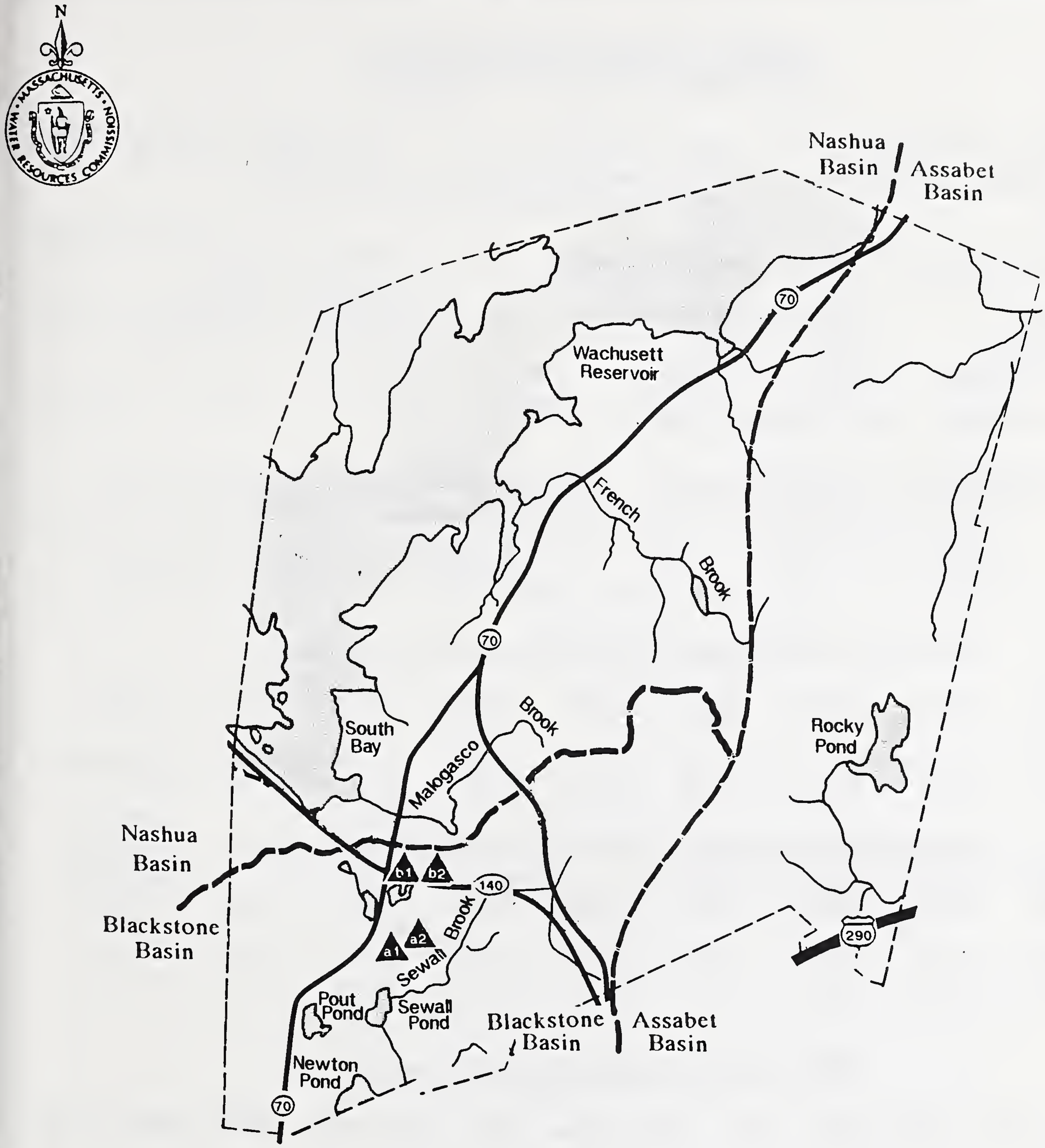
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Well # 1 (Summer & Park St)	Blackstone	0.27	0.20	B1	
Well # 4 (Elm Street)	Blackstone	0.29	0.14	B3	
Well # 5	Blackstone	0.43	0.26	B4	
Well # 2	Blackstone	0.17	0.00	B2	On line in 1989. Emergency Supply

Total ADD:	0.60 mgd

Total 1988 ADD on River Basin(s):

Blackstone	0.60 mgd



Boylston Water District	▲ BOb1	Well #1
	▲ BOb2	Well #2
Morningdale Water District	▲ BOa1	Well #1
	▲ BOa2	Well #2

LEGEND

——— River basin boundary

------- Study communities boundary

▲ Ground water source

● Surface water source

SCALE

0 ½ 1 2 Miles

Blackstone River Basin

BOYLSTON

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Boylston

Water Supply Agencies: (1) Boylston Water District
(2) Morningdale Water District

River Basin Acreage Distribution			Total Acreage
Nashua	7,233	(57%)	12,640 acres
Concord	2,886	(23%)	(9.87 sq. mi.)
Blackstone	2,521	(20%)	

CURRENT PUBLIC WATER SUPPLY USE

	Population On Public Supply		Population With On-Site Wells	
	Number	Percent	Number	Percent
(1)	1,412	40	494	14
(2)	1,624	46		

Average Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
(1)	0.15	0.23	0.19	0.17	0.17	0.20	0.20	0.21	0.25
(2)	0.15	0.17	0.16	0.19	0.15	0.19	0.21	0.23	0.21

Maximum Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
(1)	0.23	0.34	0.29	0.26	0.25	0.30	0.28	0.29	0.38
(2)	0.23	0.26	0.24	0.29	0.23	0.29	0.32	0.35	0.32

1988 Monthly Average Day Demand

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(1)	.17	.20	.20	.22	.25	.35	.30	.37	.24	.17	.25	.22
(2)	.15	.18	.23	.20	.24	.24	.20	.26	.20	.17	.23	.17

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):		Nashua	Blackstone	Concord
Volume Discharged by On-Site Septic Systems:	(1)	0.17	0.08	0
	(2)	0	0.21	0
Volume Discharged by Municipal Sewer System:		0	0	0

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Boylston
Water Supply Agencies: (1) Boylston Water District
(2) Morningdale Water District

POPULATION

1970 (U.S. Census)	1980 (U.S. Census)	1986 Census Estimate (1)	1995 (Projected) (2)	2000 (Projected) (3)	2010 (Projected) (3)	2020 (Projected) (3)
2,774	3,470	3,530	3,569	3,593	3,608	3,784

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
3,530	19.75	179

PROJECTED WATER DEMAND

Average Day Demand (mgd)

	1986-88 Base ADD	1995	2000	2010	2020
(1)	0.22	0.23	0.26	0.29	0.32
(2)	0.22	0.32	0.38	0.47	0.46

Maximum Day Demand (mgd)

	1986-88 Base MDD	1995	2000	2010	2020
(1)	0.32	0.33	0.38	0.42	0.46
(2)	0.33	0.48	0.58	0.66	0.70

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Boylston
Water Supply Agencies: (1) Boylston Water District
(2) Morningdale Water District

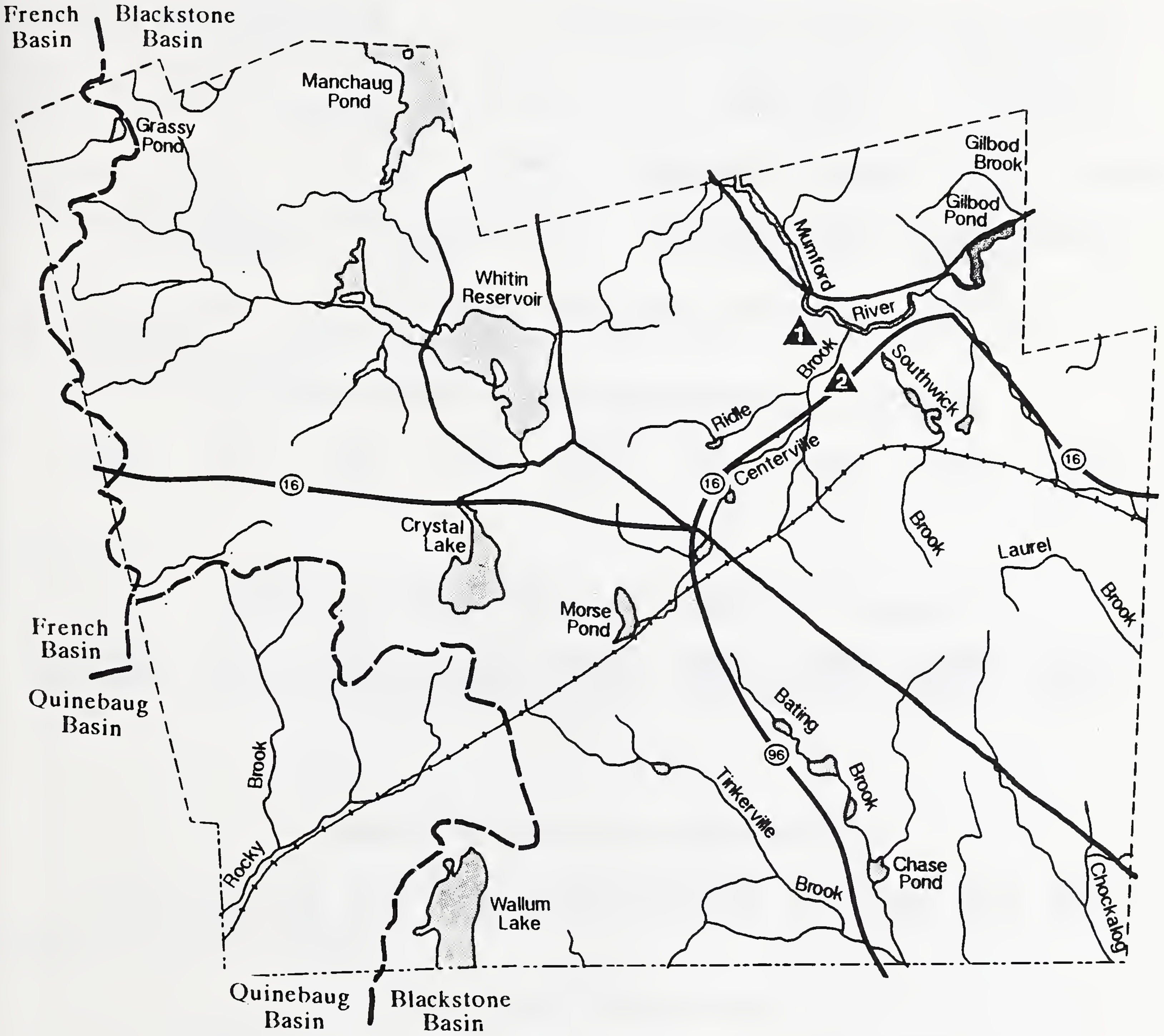
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Boylston Water District					
Well #1	Blackstone	0.86	0.25	BOb-1	
Well #2	Blackstone	0.30		BOb-2	
Morningdale Water District					
Well #1	Blackstone	0.84	0.21	BOa-1	
Well #2	Blackstone	0.33		BOa-2	

Total ADD: 0.46 mgd

Total 1988 ADD on River Basin(s):

Blackstone	0.46 mgd



LEGEND

▬ ▬ ▬ River basin boundary

– – – – Study communities boundary

▲ Ground water source

● Surface water source

▲ D1 Well #1

▲ D2 Wellfield #2

SCALE 0 ½ 1 2 Miles

Blackstone River Basin

DOUGLAS

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Douglas
Water Supply Agency: Douglas Water Department

River Basin Acreage Distribution		Total Acreage
Blackstone:	21075 (87%)	24423 (38.16 sq. mi)
Quinebaug:	3027 (12%)	
French:	321 (1%)	

CURRENT PUBLIC WATER SUPPLY USE

Population On Public Supply		Population With On-Site Wells	
Number	Percent	Number	Percent
2492	54	2111	46

(includes Seasonal Population Factor of 13)

Average Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
0.18	0.22	0.19	0.21	0.19	0.21	0.21	0.24	0.24

Maximum Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
0.46	0.49	0.33	0.43	0.32	0.39	0.39	0.65	0.33

1988 Monthly Average Day Demand

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.23	0.23	0.24	0.22	0.24	0.27	0.27	0.27	0.25	0.24	0.22	0.23

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):	Blackstone
Volume Discharged by On-Site Septic Systems:	0.22
Volume Discharged by Municipal Sewer System:	0.02

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Douglas
Water Supply Agency: Douglas Water Department

POPULATION

1970 (U.S. Census)	1980 (U.S. Census)	1986 Census Estimate (1)	1995 (Projected) (2)	2000 (Projected) (3)	2010 (Projected) (3)	2020 (Projected) (3)
2,947	3,730	4,590	5,575	6,073	6,461	6,660

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
4,590	38.16	120

PROJECTED WATER DEMAND

Average Day Demand (mgd)

1986-88 Base ADD	1995	2000	2010	2020
0.23	0.29	0.33	0.37	0.42

Maximum Day Demand (mgd)

1986-88 Base MDD	1995	2000	2010	2020
0.46	0.57	0.65	0.74	0.84

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Douglas
Water Supply Agency: Douglas Water Department

SOURCES OF PUBLIC WATER SUPPLY

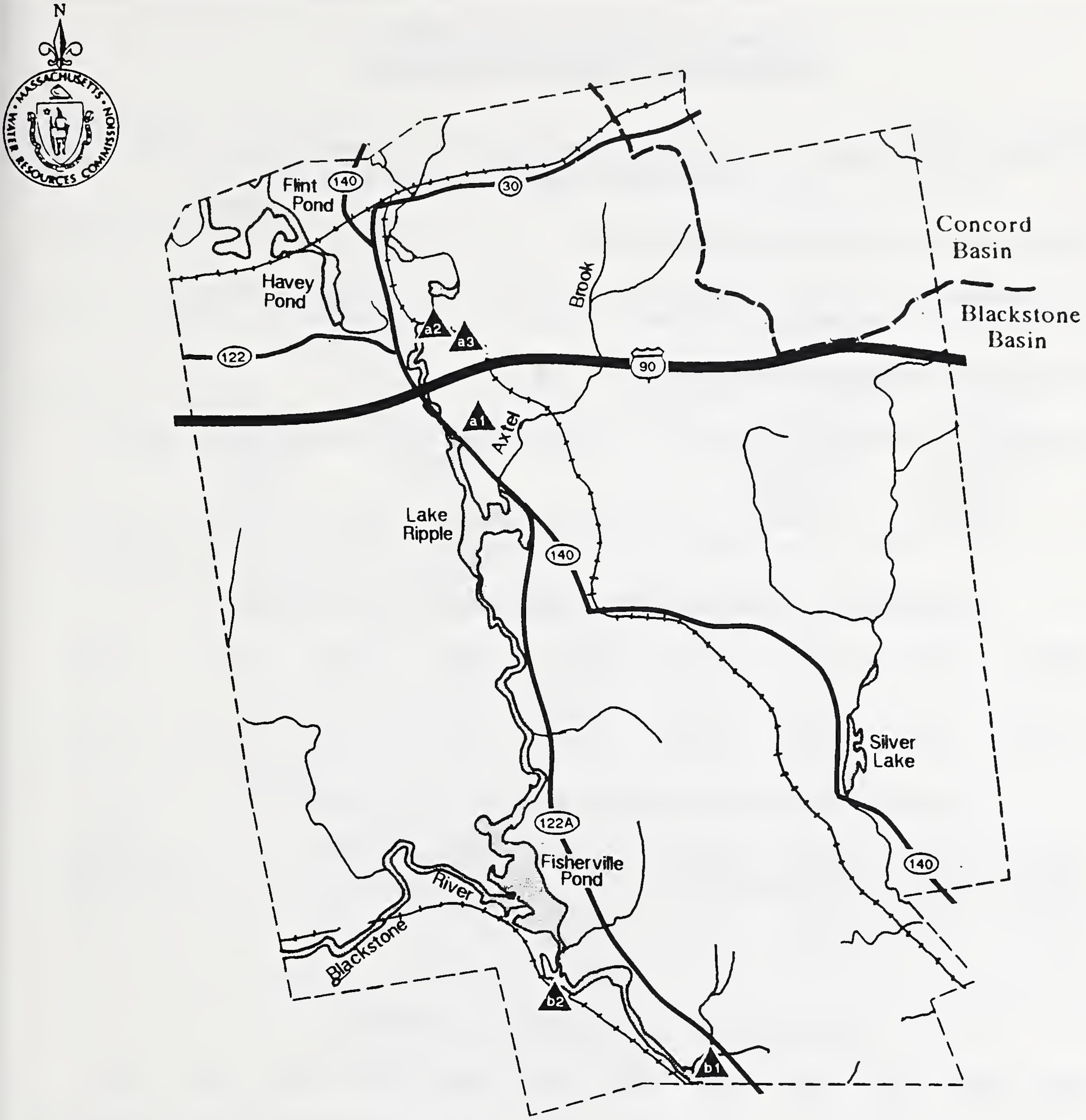
Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Well #1	Blackstone	0.43	0.10	D1	
Wellfield #2	Blackstone	0.24	0.14	D2	

Total ADD: 0.24 mgd

Total 1988 ADD
on River Basin(s):

Blackstone	0.24	mgd

MASSACHUSETTS WATER RESOURCES COMMISSION



LEGEND

━ ━ ━ River basin boundary

- - - - - Study communities boundary

▲ Ground water source

● Surface water source

Grafton Water District	▲ Ga1	Worcester St., Well
	▲ Ga2	East St., Well #2
	▲ Ga3	East St., Well #3
So. Grafton Water District	▲ Gb1	Providence Rd. Well
	▲ Gb2	Ferry St., Well #1

SCALE

0 ½ 1 2 Miles

Blackstone River Basin

GRAFTON

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Grafton

Water Supply Agencies:
(1) Grafton Water Disrict
(2) South Grafton Water District

River Basin Acreage Distribution			Total Acreage
Blackstone	13,930	(93%)	14,943 acres
Concord	1,013	(7%)	(23.35 sq. mi.)

CURRENT PUBLIC WATER SUPPLY USE

	Population On Public Supply		Population With On-Site Wells	
	Number	Percent	Number	Percent
(1)	6,749	57%	2,131	18%
(2)	2,960	25%		

Average Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
(1)	0.64	0.57	0.56	0.62	0.56	0.88	0.66	0.73	0.76
(2)	0.18	ND	ND	ND	0.19	0.19	0.20	0.17	0.18

Maximum Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
(1)	1.02	0.94	1.19	1.02	1.18	1.74	1.46	1.48	1.35
(2)	ND	ND	ND	ND	0.29	0.29	0.30	0.26	0.27

1988 Monthly Average Day Demand

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
(1)	.79	.60	.70	.67	.77	.89	.79	.91	.77	.69	.73	.73
(2)	.20	.17	.16	.21	.17	.19	.19	.15	.15	.19	.16	.19

1988 WASTEWATER DISCHARGE:	Grafton W.D.	S. Grafton W.D.
Receiving River Basin(s):	Blackstone	Blackstone
Volume Discharged by On-Site Septic Systems:	0.30	0.12
Volume Discharged by Municipal Sewer System:	0.46	0.06

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Grafton

Water Supply Agencies: (1) Grafton Water District
(2) South Grafton Water District

POPULATION

1970 (U.S. Census)	1980 (U.S. Census)	1986 Census Estimate (1)	1995 (Projected) (2)	2000 (Projected) (3)	2010 (Projected) (3)	2020 (Projected) (3)
11,659	11,238	11,840	12,537	12,765	12,958	13,571

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
11,840	23.35	507

PROJECTED WATER DEMAND

Average Day Demand (mgd)

	1986-88 Base ADD	1995	2000	2010	2020
(1)	0.76*	0.82	0.94	1.12	1.28
(2)	0.18	0.20	0.21	0.23	0.26

* 1988 ADD used for base

Maximum Day Demand (mgd)

	1986-88 Base MDD	1995	2000	2010	2020
(1)	1.43	1.66	1.88	2.26	2.58
(2)	0.28	0.30	0.33	0.35	0.40

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Grafton

Water Supply Agencies: (1) Grafton Water District
(2) South Grafton Water District

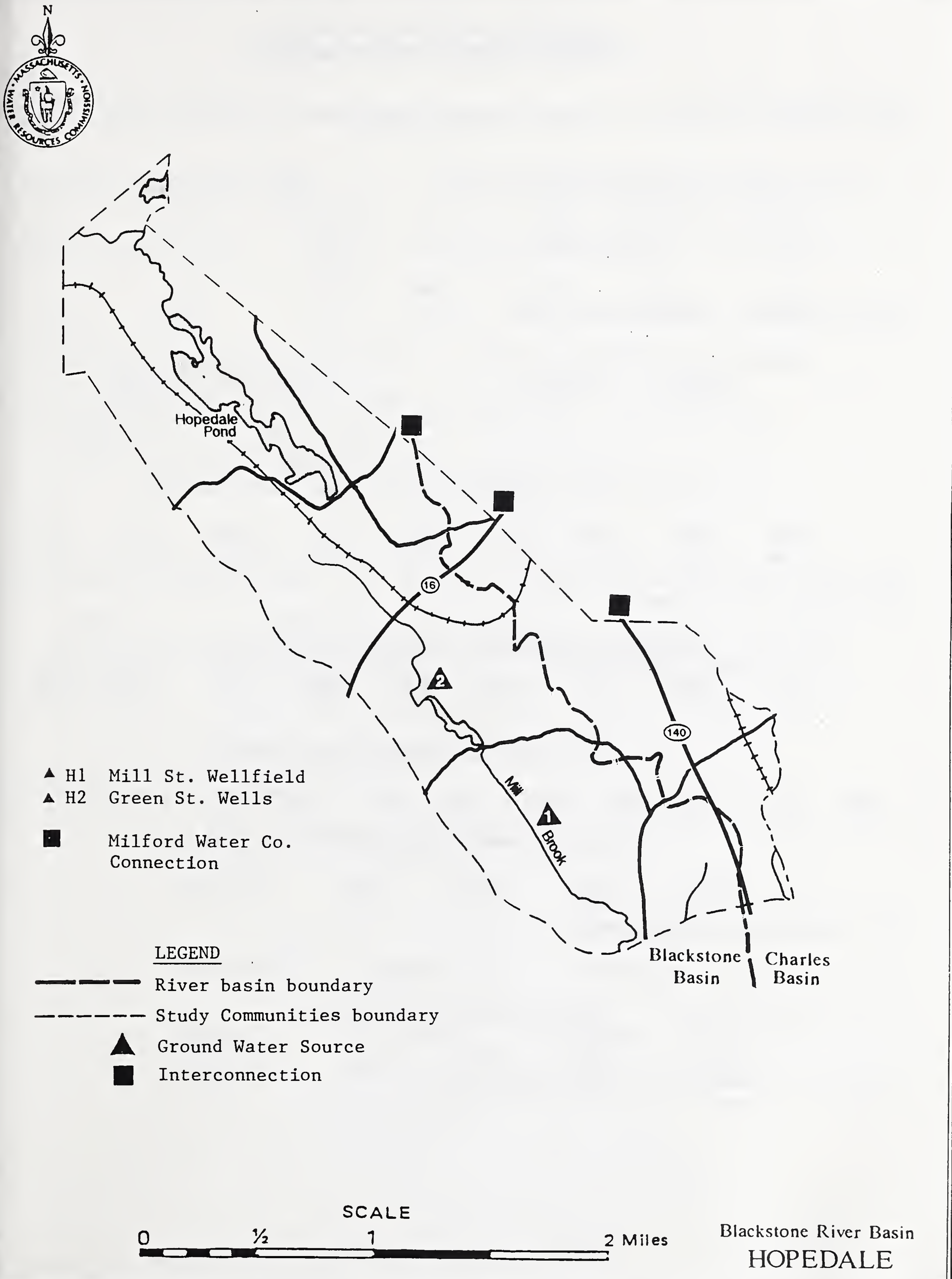
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Grafton Water District					
Worcester St.	Blackstone	1.00	0.68	Ga-1	
East St. #2	Blackstone	0.61	0.08	Ga-2	Back-up
East St. #3	Blackstone	1.00	0.00	Ga-3	Emergency
South Grafton Water District					
Providence Rd.	Blackstone	0.36	0.05	Gb-1	
Ferry St. #1	Blackstone	0.35	0.13	Gb-2	

Total ADD: 0.94 mgd

Total 1988 ADD on River Basin(s):

Blackstone	0.94 mgd



Blackstone River Basin
HOPEDALE

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Hopedale
Water Supply Agency: Hopedale Water Department

River Basin Acreage Distribution		Total Acreage
Blackstone:	2476 (81%)	3399 acres (5.31 sq. mi)
Charles:	653 (19%)	

CURRENT PUBLIC WATER SUPPLY USE

Population On Public Supply		Population With On-Site Wells	
Number	Percent	Number	Percent
4750	86	750	14

Average Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
0.48	0.46	0.54	0.62	0.57	0.56	0.60	0.43	0.47

Due to a malfunctioning meter, demands are higher than the actual until 1987 which was adjusted.

Maximum Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
0.83	0.79	0.93	1.06	0.98	0.96	1.03	0.86	0.60

1988 Monthly Average Day Demand

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.32	0.34	0.79*	0.32	0.34	0.73*	0.31	0.37	0.85*	0.34	0.33	0.6

*Includes water purchased from Milford.

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):	Blackstone	Charles
Volume Discharged by On-Site Septic Systems:	0.09	0.04
Volume Discharged by Municipal Sewer System:	0.34	0

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Hopedale
Water Supply Agency: Hopedale Water Department

POPULATION

1970 (U.S. Census)	1980	1989 Town Census (1)	1995 (Projected) (2)	2000 (3)	2010 (3)	2020 (3)
4292	3905	5500	5537	5573	5804	6102

(1) Prepared by the town of Hopedale
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1989 Census Estimate	Area of Community (in square miles)	1989 Population Density (persons per square mile)
5500	5.31	1035

PROJECTED WATER DEMAND

Average Day Demand (mgd)

1986-88 Base ADD	1995	2000	2010	2020
0.50	0.54	0.59	0.67	0.74

Maximum Day Demand (mgd)

1986-88 Base MDD	1995	2000	2010	2020
0.83	0.89	0.97	1.12	1.23

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community:Hopedale
Water Supply Agency: Hopedale Water Department

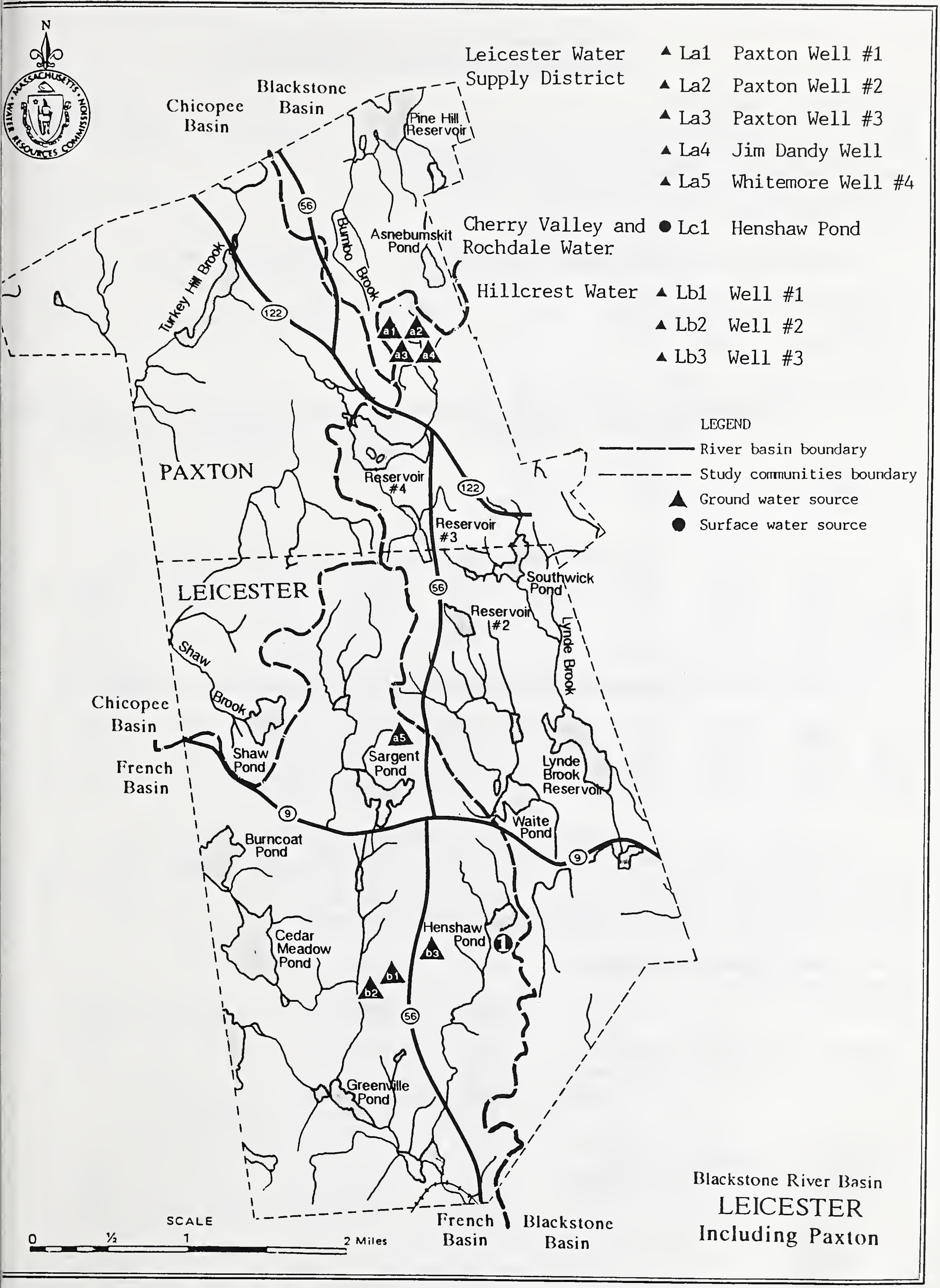
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Mill Street Wellfield	Blackstone	0.40	0.29	H 1	
Greene Street Wells	Blackstone	0.10	0.04	H 2	1988 Used Aug - Sept. usually yr round 12 hr/day
			---------		
			0.33		
Town of Milford	Charles		0.14		

Total ADD:		0.47 mgd

Total 1988 ADD on River Basin(s):

Blackstone	0.33 mgd
Charles	0.14 mgd



Blackstone River Basin
LEICESTER
Including Paxton

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Leicester

Water Supply Agencies:
Leicester Water Supply District (LWS)
Cherry Valley & Rochdale Water District (CVR)
Hillcrest Water District (HWD)

River Basin Acreage Distribution			Total Acreage
Blackstone:	5218	(33%)	15769 acres (24.64 sq.mi.)
French:	8864	(56%)	
Chicopee:	1687	(11%)	

CURRENT PUBLIC WATER SUPPLY USE

	Population On Public Supply		Population With On-Site Well	
	Number	Percent	Number	Percent
LWS	3388	35		
CVR	4453	46		
HWD	968	10		
	8809	91	871	9

Average Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
LWS	0.18	0.18	ND	0.19	0.20	0.19	0.19	0.20	0.20
CVR	0.30	0.32	0.27	0.24	0.27	0.25	0.24	0.27	0.26
HWD	0.15	0.12	0.14	ND	0.06	0.06	0.06	0.07	0.07

Maximum Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
LWS	0.29	0.24	ND	0.25	0.26	0.30	0.27	0.27	0.27
CVR	0.55	0.48	0.48	0.64	0.56	0.40	0.44	0.43	0.49
HWD	0.18	0.18	0.14	ND	0.09	0.09	0.09	0.11	0.10

1988 Monthly Average Day Demand(mgd)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
LWS	0.19	0.22	0.21	0.22	0.23	0.23	0.19	0.19	0.21	0.20	0.20	0.16
CVR	0.28	0.28	0.26	0.20	0.23	0.29	0.27	0.28	0.26	0.25	0.24	0.23
HWD	0.06	0.06	0.06	0.07	0.07	0.08	0.07	0.07	0.07	0.06	0.07	0.06

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):	AGENCY	Blackstone	French
Volume Discharged (mgd) by On-Site Septic Systems:	LWS	0.03	0
	CVR	0.14	0.12
	HWD	--	0.07
	TOTAL	0.17	0.19
Volume Discharged (mgd) by Municipal Sewer System:	LWS	--	0.17
	CVR	--	--
	HWD	--	--
	TOTAL	--	0.17

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Leicester

Water Supply Agencies:
Leicester Water Supply District
Cherry Valley and Rochdale Water Dist.
Hillcrest Water District

POPULATION

1970 (U.S. Census)	1980 (U.S. Census)	1986 Census Estimate (1)	1995 (Projected) (2)	2000 (Projected) (3)	2010 (Projected) (3)	2020 (Projected) (3)
9,140	9,446	9,680	9,844	9,951	10,012	10,526

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
9,680	24.64	393

PROJECTED WATER DEMAND

Average Day Demand (mgd)

	1986-88 Base ADD	1995	2000	2010	2020
LWS	0.20	0.21	0.25	0.26	0.29
CVR	0.26	0.27	0.31	0.32	0.35
HWD	0.07	0.07	0.08	0.08	0.09

Maximum Day Demand (mgd)

	1986-88 Base MDD	1995	2000	2010	2020
LWS	0.27	0.28	0.33	0.35	0.39
CVR	0.45	0.48	0.54	0.57	0.63
HWD	0.10	0.11	0.11	0.12	0.13

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Leicester

Water Supply Agencies:
Leicester Water Supply District
Cherry Valley & Rochdale Water District
Hillcrest Water District

SOURCES OF PUBLIC WATER SUPPLY

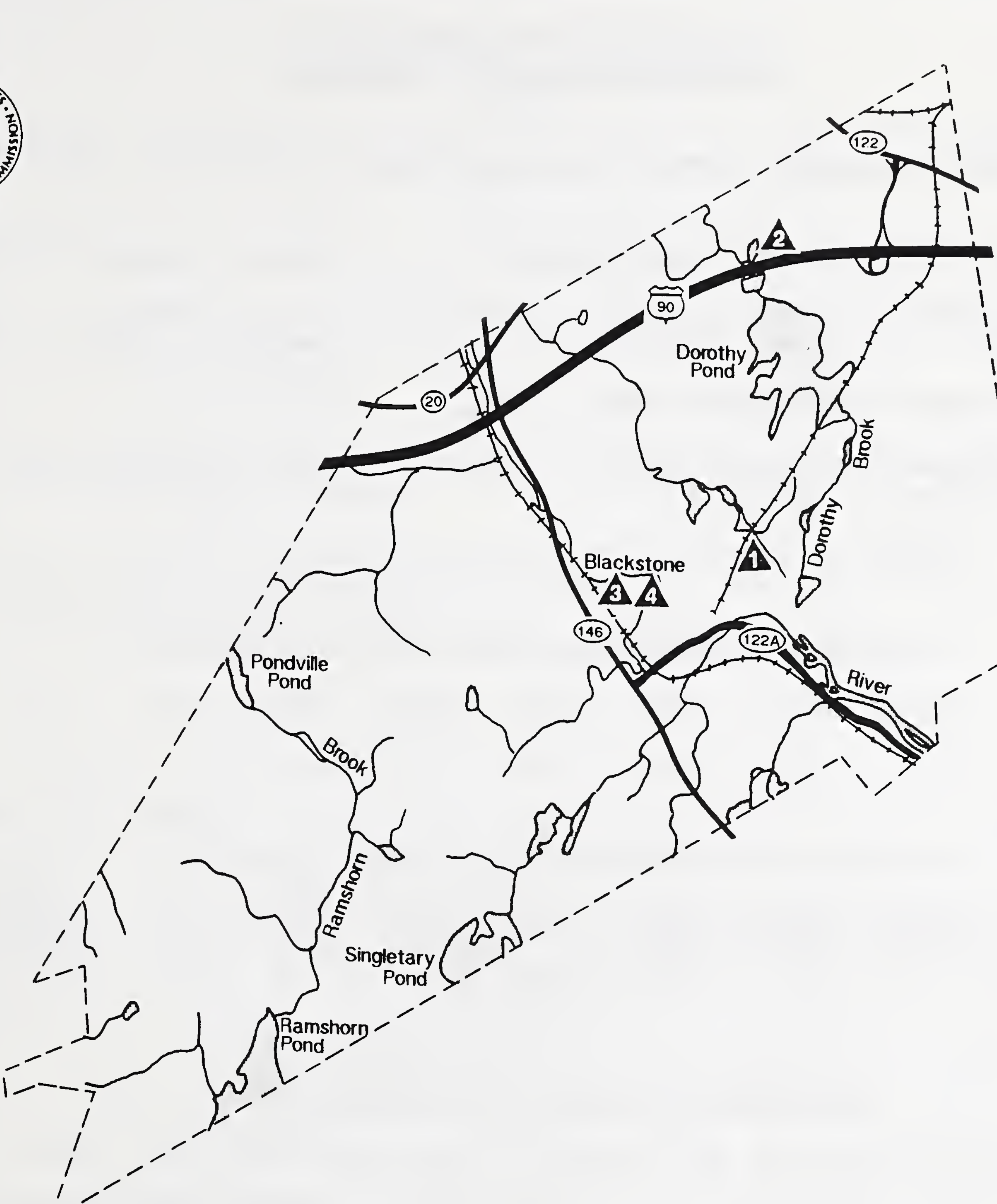
Agency & Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Leicester WSD					
Paxton #1	Blackstone	0.07		La1	
Paxton #2	"	0.12		La2	
Paxton #3	"	0.17	0.17	La3	
Jim Dandy	"	0.10		La4	
Whitemore #4	French	0.07	0.03	La5	
Cherry Valley & Rochdale WD					
Henshaw Pond	French	0.70	0.26	Lc1	
Hillcrest WD					
Well #1	French	0.09	---	Lb1	stand-by
Well #2	French	0.14	0.07	Lb2	
Well #3	French	0.09	---	Lb3	stand-by

Total ADD: 0.53 mgd

Total 1988 ADD on River Basin(s):

Blackstone	0.17 mgd
French	0.36 mgd

MASSACHUSETTS WATER RESOURCES COMMISSION



Mass. American
Water Company

▲ M1	Millbury Ave. Well
▲ M2	Oak Pond Well
▲ M3	North Main #1
▲ M4	North Main #2

LEGEND

——— River basin boundary

- - - - - Study communities boundary

▲ Ground water source

● Surface water source

SCALE

0 ½ 1 2 Miles

Blackstone River Basin

MILLBURY

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Millbury
Water Supply Agency: Mass. American Water Company

River Basin Acreage Distribution			Total Acreage
Blackstone:	10,440	(99 %)	10,478 acres
French:	34	(1 %)	(16.37 sq. mi.)

CURRENT PUBLIC WATER SUPPLY USE

Population On Public Supply		Population With On-Site Wells	
Number	Percent	Number	Percent
9,886	83	1954	17

Average Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
1.19	0.99	0.93	1.02	1.09	0.99	1.15	1.09	1.67

Maximum Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
1.67	1.70	1.37	1.54	1.70	1.97	2.13	1.63	2.85

1988 Monthly Average Day Demand (mgd)

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1.1	1.3	1.5	1.7	1.8	2.0	1.9	1.9	1.8	1.8	1.7	1.7

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):	Blackstone
Volume Discharged by On-Site Septic Systems:	1.00
Volume Discharged by Municipal Sewer System:	0.67

OFFICE OF WATER RESOURCES

WATER SUPPLY FACTS - SUMMARY

Community: Millbury
Water Supply Agency: Mass. American Water Company

POPULATION

1970	1980	1986	1995	2000	2010	2020
(U.S. Census)		Census Estimate	(Projected)			
		(1)	(2)	(3)	(3)	(3)
11,987	11,808	11,840	11,693	11,752	11,747	12,373

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
11,840	16.37	723

PROJECTED WATER DEMAND

Average Day Demand (mgd)

1988 Base ADD	1995	2000	2010	2020
1.67	1.76	1.92	2.03	2.26

Maximum Day Demand (mgd)

1988 Base MDD	1995	2000	2010	2020
2.85	3.01	3.28	3.47	3.86

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Millbury
Water Supply Agency: Mass. American Water Company

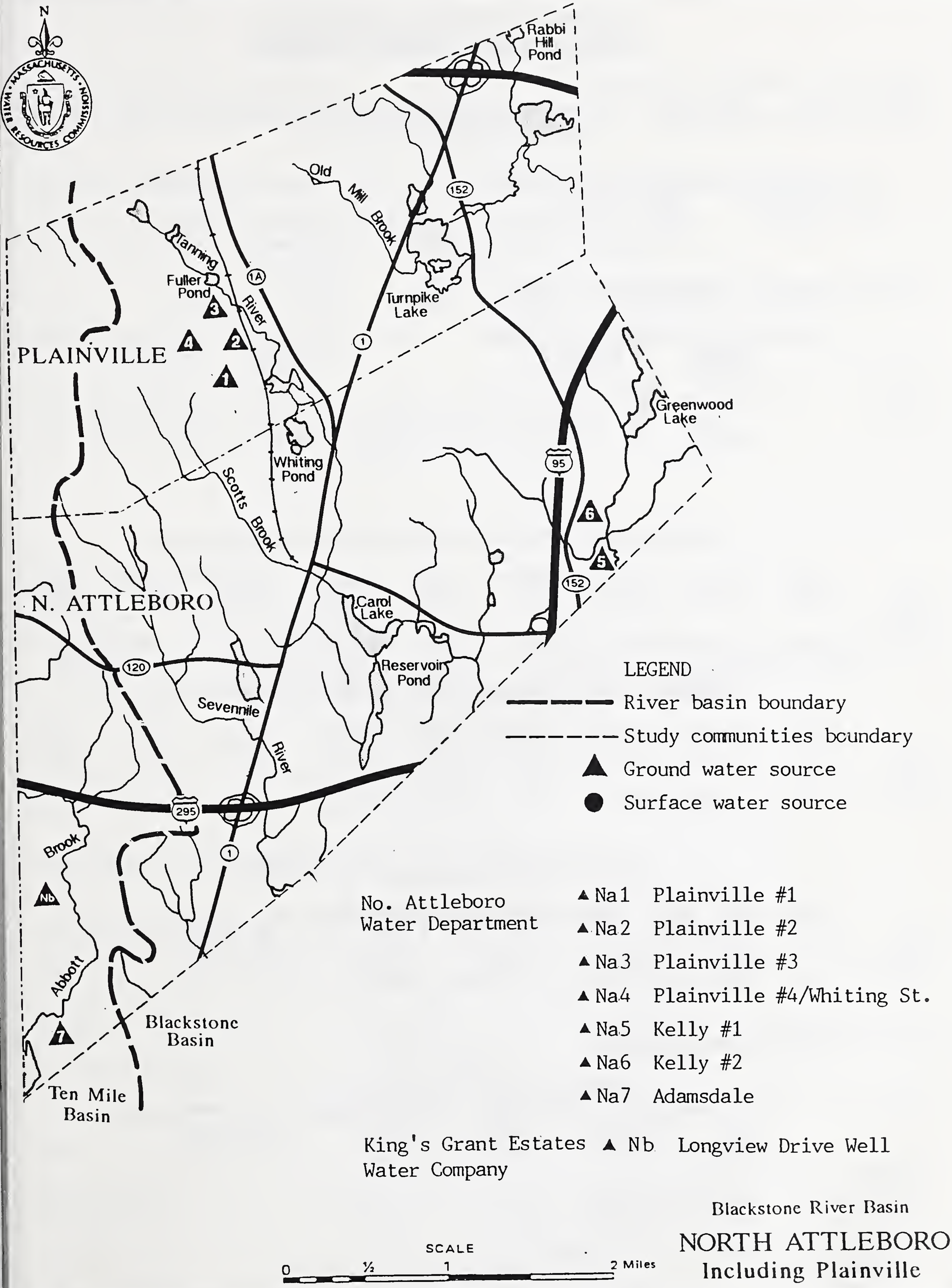
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Millbury Ave. Well	Blackstone	1.40	0.48	M1	
Oak Pond Well	Blackstone	1.01	0.51	M2	
No. Main #1	Blackstone	0.86	0.40	M3	
No. Main #2	Blackstone	0.50	0.28	M4	
Purchased Water from Worcester			0.02		
Water Sold to Grafton			(0.01)		

Total ADD: 1.67 mgd

Total 1988 ADD on River Basin(s):

Blackstone	1.67 mgd



No. Attleboro Water Department	▲ Na1	Plainville #1
	▲ Na2	Plainville #2
	▲ Na3	Plainville #3
	▲ Na4	Plainville #4/Whiting St.
	▲ Na5	Kelly #1
	▲ Na6	Kelly #2
	▲ Na7	Adamsdale
King's Grant Estates Water Company	▲ Nb	Longview Drive Well

Blackstone River Basin

NORTH ATTLEBORO
Including Plainville

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: North Attleboro
Water Supply Agencies: North Attleboro Water Division
King's Grant Estates

River Basin Acreage Distribution		Total Acreage
Blackstone:	2561 (21%)	
Ten Mile:	9674 (78%)	12416 acres (19.4 sq. mi)

CURRENT PUBLIC WATER SUPPLY USE

	Population On Public Supply		Population With On-Site Wells	
	Number	Percent	Number	Percent
DPW	22287	95	704	3
Kings Grant	469	2		
	22756	97		

Average Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
DPW	2.55	2.43	2.60	2.44	2.30	2.07	2.06	2.51	2.84
Kings Grant	NA	NA	NA	NA	0.04	0.04	0.04	0.05	0.07

Maximum Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
DPW	4.64	4.10	4.10	4.32	3.43	3.81	3.98	5.15	5.41
Kings Grant	NA	NA	NA	NA	0.06	0.06	0.06	0.08	0.13

1988 Monthly Average Day Demand

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DPW	2.51	2.42	2.50	2.49	2.67	4.16	3.51	3.62	2.65	2.43	2.43	2.67
Kings Grant	0.06	0.04	0.06	0.07	0.07	0.09	0.09	0.09	0.08	0.08	0.08	0.08

1988 WASTEWATER DISCHARGE:

	DPW		King's Grant
Receiving River Basin(s):	Ten Mile	Blackstone	Blackstone
Volume Discharged by On-Site Septic Systems:	1.31	0.11	0.07
Volume Discharged by Municipal Sewer System:	1.42	0	0

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: North Attleboro
Water Supply Agencies: North Attleboro DPW, Water Div.
King's Grant Estates

POPULATION

1970 (U.S. Census)	1980 (U.S. Census)	1986 Census Estimate (1)	1995 (Projected) (2)	2000 (Projected) (3)	2010 (Projected) (3)	2020 (Projected) (3)
18665	21095	23460	26781	28863	29949	31684

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the town of North Attleboro
(3) OWR's extension of MISER Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
23460	19.40	1209

PROJECTED WATER DEMAND

Average Day Demand (mgd)

	1986-88 Base ADD	1995	2000	2010	2020
DPW	2.47	2.89	3.26	3.58	3.96
King's Grant	0.05	0.06	0.06	0.07	0.08

Maximum Day Demand (mgd)

	1986-88 Base MDD	1995	2000	2010	2020
DPW	4.85	5.66	6.39	7.01	7.76
King's Grant	0.09	0.11	0.12	0.13	0.14

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: North Attleboro

Water Supply Agencies: North Attleboro DPW, Water Div.
King's Grant Estates

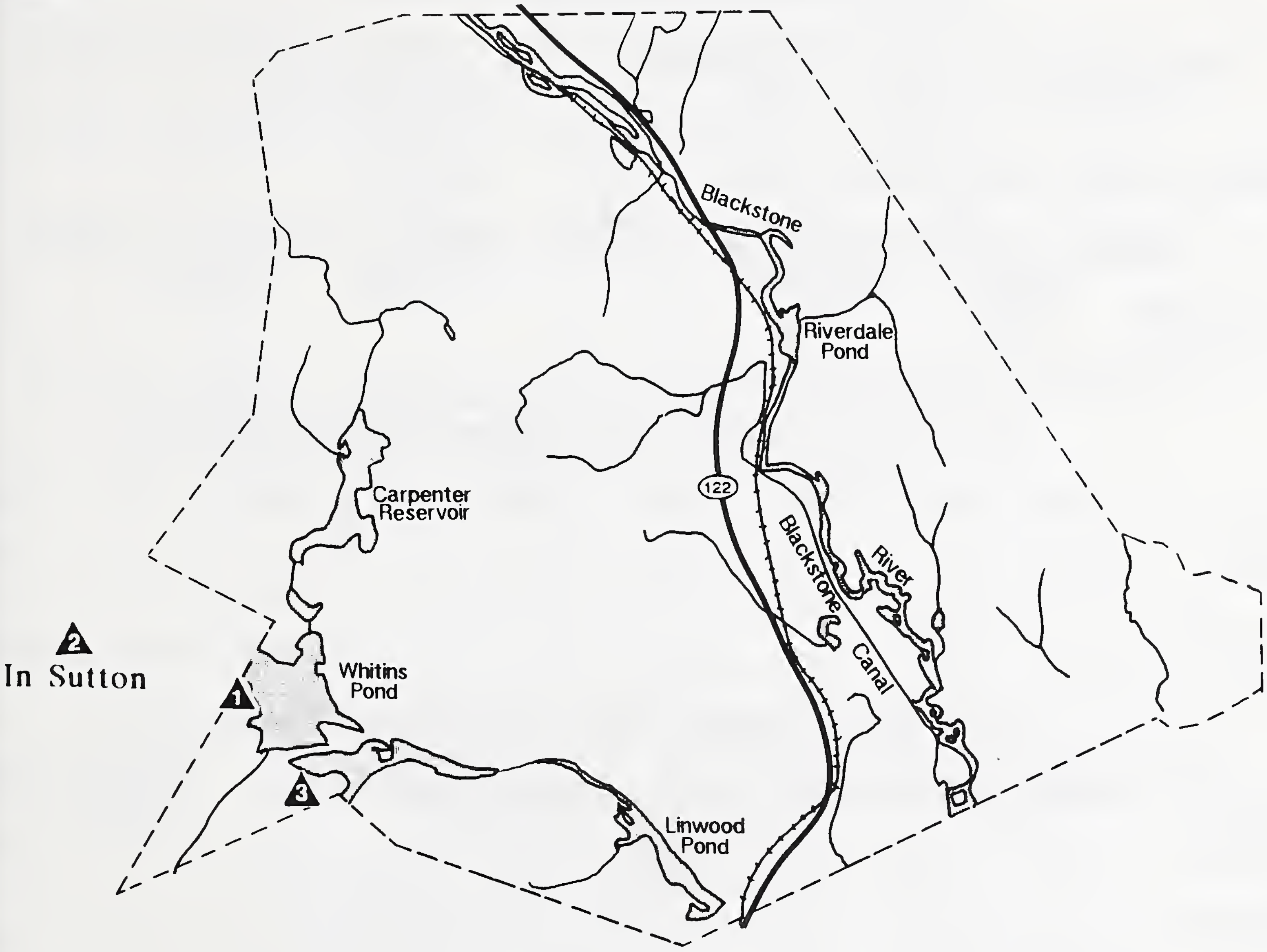
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
DPW:					
Plainville 1	Ten Mile	1.34	0.88	Na 1	
Plainville 2	Ten Mile			Na 2	
Plainville 3	Ten Mile			Na 3	
Plainville 4/ Whiting St.	Ten Mile	1.25	0.61	Na 4	Pumped into Whiting well
Kelly 1	Ten Mile	0.67	0.38	Na 5	
Kelly 2	Ten Mile	0.67	0.36	Na 6	
Adamsdale	Blackstone	0.67	0.53	Na 7	
Water Purchased from Attleboro	Ten Mile		0.08		
			2.84		
Kings Grant:					
Mendon Rd. Well	Blackstone	0.40	0.07	Nb	

Total ADD: 2.91 mgd

Total 1988 ADD on River Basin(s):

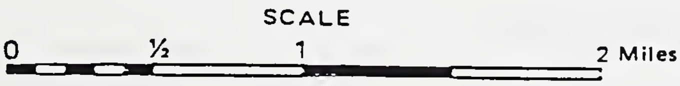
DPW	Blackstone	0.53 mgd
	Ten Mile	2.31 mgd
King's Grant	Blackstone	0.07 mgd



LEGEND

- ▬▬▬ River basin boundary
- - - - - Study communities boundary
- ▲ Ground water source
- ● Surface water source

Whitinsville Water Co.	▲ N1	Whiten Pump Station
	▲ N2	Sutton Pump Station
	▲ N3	Gravel Pack Well
Northbridge Water Co.		Purchases water from Whitinsville Water Co.



Blackstone River Basin

NORTHBRIDGE

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community:Northbridge
Water Supply Agencies: Northbridge Water Department
Whitinsville Water Company

River Basin Acreage Distribution	Total Acreage
Blackstone: 11545 (100%)	11545 acres(18.04 sq. ml)

CURRENT PUBLIC WATER SUPPLY USE

	Population On Public Supply		Population With On-Site Wells	
	Number	Percent	Number	Percent
N.Bridge	4852	39	1990	16
Whitins.	5790*	45		

*(192 out of town customers)

Average Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
North-bridge	0.40	0.37	0.44	0.42	0.43	0.40	0.42	0.55	0.36
Whitins-vill	0.73	0.80	0.69	0.66	0.64	0.62	0.58	0.59	0.76

Maximum Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
North-bridge	0.60	0.56	0.66	0.63	0.65	0.60	0.63	0.83	0.54
Whitins-ville	1.65	1.68	1.70	1.70	1.42	2.01	1.61	1.59	1.89

1988 Monthly Average Day Demand

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
North-bridge	0.39	0.29	0.42	0.32	0.27	0.50	0.04	0.32	0.53	0.35	0.29	0.65
Whitins-ville	0.71	0.79	0.63	0.77	0.82	0.89	1.24	0.95	0.54	0.67	0.74	0.35

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s): Blackstone

Volume Discharged
by On-Site Septic Systems: 0.11 Northbridge
0.08 Whitinsville

Volume Discharged by Municipal
Sewer System: 0.25 Northbridge
0.68 Whitinsville
1.12

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community:Northbridge
Water Supply Agencies: Northbridge Water Department
Whitinsville Water Company

POPULATION

1970 (U.S. Census)	1980 (U.S. Census)	1986 Census Estimate (1)	1995 (Projected) (2)	2000 (Projected) (3)	2010 (Projected) (3)	2020 (Projected) (3)
11795	12246	12440	12869	12888	12957	13630

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
12440	18.04	690

PROJECTED WATER DEMAND

Average Day Demand (mgd)

	1986-88 Base ADD	1995	2000	2010	2020
Northbridge	0.44	0.47	0.54	0.65	0.71
Whitinsville	0.64	0.66	0.75	0.79	0.87

Maximum Day Demand (mgd)

	1986-88 Base MDD	1995	2000	2010	2020
Northbridge	0.67	0.71	0.82	0.98	1.08
Whitinsville	1.70	1.74	1.98	2.09	2.30

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Northbridge
Water Supply Agencies: Northbridge Water Department
Whitinsville Water Company

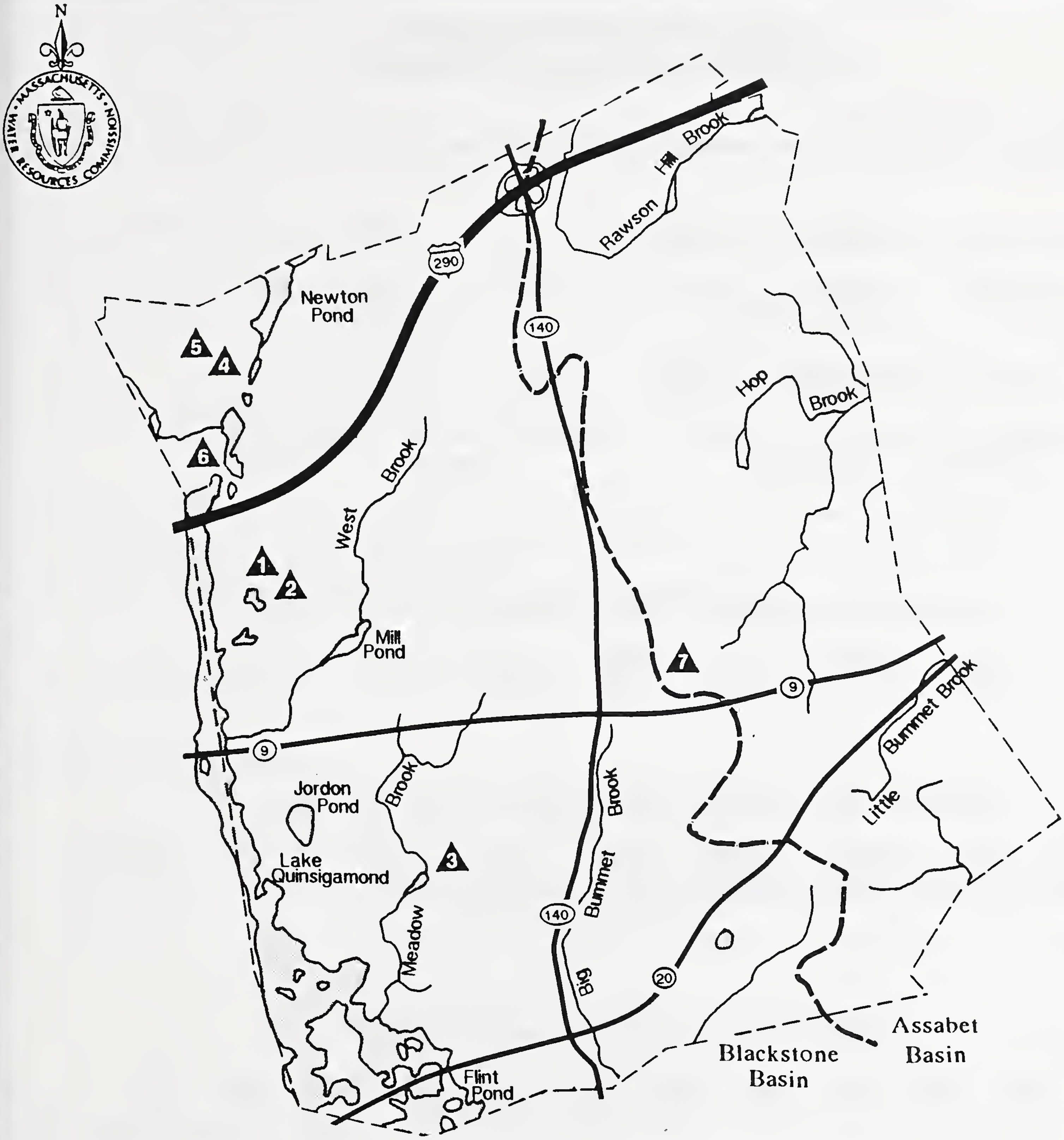
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Northbridge: Purchased from Whitinsville Water Company	Blackstone	See Below	0.36	---	---
Whitinsville: Whitins Wellfield	Blackstone	2.0	0.60	N1	
Sutton Wellfield	Blackstone	1.5	0.53	N2	
Gravel Packed Well	Blackstone	0.50	0	N 3	Emergency
Sold to Northbridge Water Co:		<0.36>			

Total ADD: 1.12 mgd

Total 1988 ADD on River Basin(s):

Northbridge Water Company	Blackstone	0.36 mgd
Whitinsville Water Company	Blackstone	0.76 mgd



▲	S1	Lambert Well #1
▲	S2	Lambert Well #2
▲	S3	Oak St., Well #3
▲	S4	Sewall St. Well #4
▲	S5	Sewall St. Well #5
▲	S6	Home Farm Well #6
▲	S7	South St. Well #7

LEGEND

——— River basin boundary
- - - - Study communities boundary
▲ Ground water source
● Surface water source

SCALE
0 ½ 1 2 Miles

Blackstone River Basin
SHREWSBURY

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Shrewsbury
Water Supply Agency: Shrewsbury Water Department

River Basin Acreage Distribution			Total Acreage
Blackstone	9,003	(65%)	13,919 acres
Concord	4,916	(35%)	

CURRENT PUBLIC WATER SUPPLY USE

Population On Public Supply		Population With On-Site Wells	
Number	Percent	Number	Percent
21,432	95	1,128	5

Average Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
2.55	2.90	2.72	2.48	2.70	2.79	3.13	3.20	3.19

Maximum Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
4.44	4.97	4.72	4.64	4.44	4.79	5.07	6.13	6.10

1988 Monthly Average Day Demand

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2.4	3.3	2.7	2.7	3.1	4.2	4.0	4.0	3.5	2.8	2.8	2.9

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):	Blackstone	Concord
Volume Discharged by On-Site Septic Systems:	0.85	0.27
Volume Discharged by Municipal Sewer System:	0.00	2.07

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Shrewsbury
Water Supply Agency: Shrewsbury Water Department

POPULATION

1970 (U.S. Census)	1980 (U.S. Census)	1986 Census Estimate (1)	1995 (Projected) (2)	2000 (Projected) (3)	2010 (Projected) (3)	2020 (Projected) (3)
19,196	22,674	22,560	22,792	22,696	22,706	23,910

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
22,560	21.75	1,037

PROJECTED WATER DEMAND

Average Day Demand (mgd)

1986-88 Base ADD	1995	2000	2010	2020
3.17	3.28	3.45	3.66	4.07

Maximum Day Demand (mgd)

1986-88 Base MDD	1995	2000	2010	2020
5.77	5.97	6.29	6.66	7.40

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Shrewsbury
Water Supply Agency: Shrewsbury Water Department

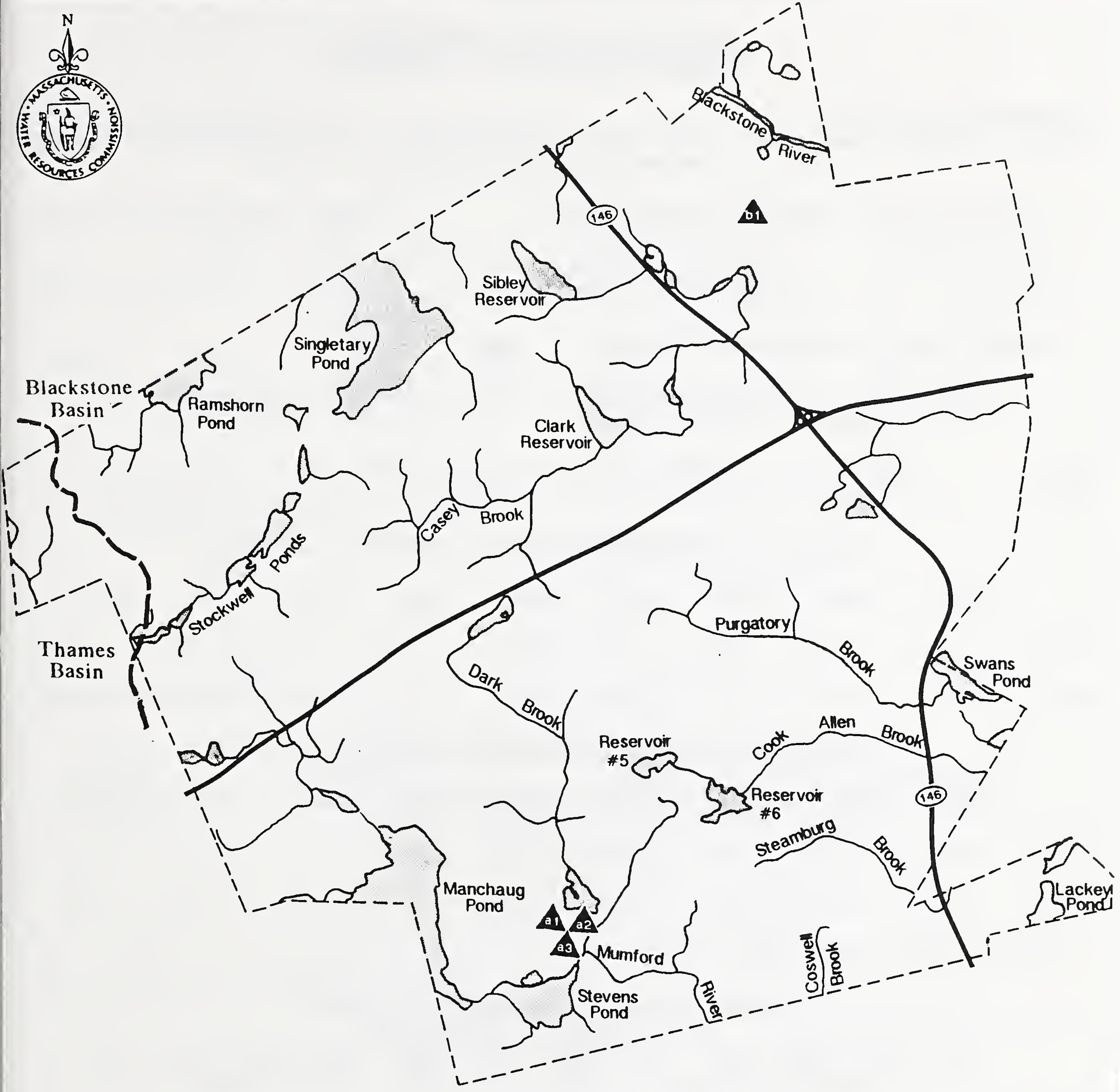
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Lambert #1	Blackstone	0.76	0.34	S1	
Lambert #2	Blackstone	0.47	0.05	S2	
Oak St. #3	Blackstone	0.40	0.00	S3	Back on-line 1989
Sewell St. #4	Blackstone	1.14	0.86	S4	
Sewell St. #5	Blackstone	0.72	0.27	S5	
Home Farm #6	Blackstone	2.88	1.50	S6	Building treatment plant
South St. #7	Concord	0.32	0.17	S7	

Total ADD: 3.19 mgd

Total 1988 ADD on River Basin(s):

Blackstone	3.02 mgd
Concord	0.17 mgd



Wilkinsonville Water District	▲ Sub1	Hatchery Road Well
Manchaug Water District	▲ Sua1	Manchaug Well #1
	▲ Sua2	Manchaug Well #2
	▲ Sua3	Manchaug Well #3

LEGEND

▬ ▬ ▬ River basin boundary

- - - - - Study communities boundary

▲ Ground water source

● Surface water source

SCALE

0 ½ 1 2 Miles

Blackstone River Basin

SUTTON

DEM/Division of Water Resources

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Sutton

Water Supply Agencies: Wilkinsonville Water District (WWD)
Manchaug Water District (MWD)

River Basin Acreage Distribution		Total Acreage
Blackstone:	21397 (98%)	21813 (34.08 sq. ml.)
French:	416 (2%)	

CURRENT PUBLIC WATER SUPPLY USE

	Population On Public Supply		Population With On-Site Wells	
	Number	Percent	Number	Percent
WWD	1000	15	5190	79
MWD	400	6		

Average Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
WWD	0.10	0.12	ND	0.07	ND	0.08	0.10	0.08	0.08
MWD	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03

Maximum Day Demand (million gallons per day)

	1980	1981	1982	1983	1984	1985	1986	1987	1988
WWD	0.18	0.20	ND	0.10	ND	ND	0.13	0.14	0.14
MWD	0.03	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

ND indicates no data available.

1988 Monthly Average Day Demand

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
WWD												
MWD												

Not Broken Down By Monthly Consumptions

1988 WASTEWATER DISCHARGE:

	Wilkinsonville	Manchaug
Receiving River Basin(s):	Blackstone	Blackstone
Volume Discharged by On-Site Septic Systems:	0.00	0.03
Volume Discharged by Municipal Sewer System:	0.08	0.00

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Sutton

Water Supply Agencies: Wilkinsonville Water District (WWD)
Manchaug Water District (MWD)

POPULATION

1970	1980	1986	1995	2000	2010	2020
(U.S. Census)		Census Estimate	(Projected)			
		(1)	(2)	(3)	(3)	(3)
4590	5885	6590	7284	7673	7929	8281

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
6590	34.08	193

PROJECTED WATER DEMAND

Average Day Demand (mgd)

	1986-88 Base ADD	1995	2000	2010	2020
WWD	0.09	0.11	0.15	0.20	0.26
MWD	0.03	0.03	0.04	0.04	0.04

Maximum Day Demand (mgd)

	1986-88 Base MDD	1995	2000	2010	2020
WWD	0.14	0.18	0.23	0.31	0.40
MWD	0.05	0.06	0.06	0.07	0.07

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community:Sutton
Water Supply Agencies: Wilkinsonville Water District (WWD)
Manchaug Water District (MWD)

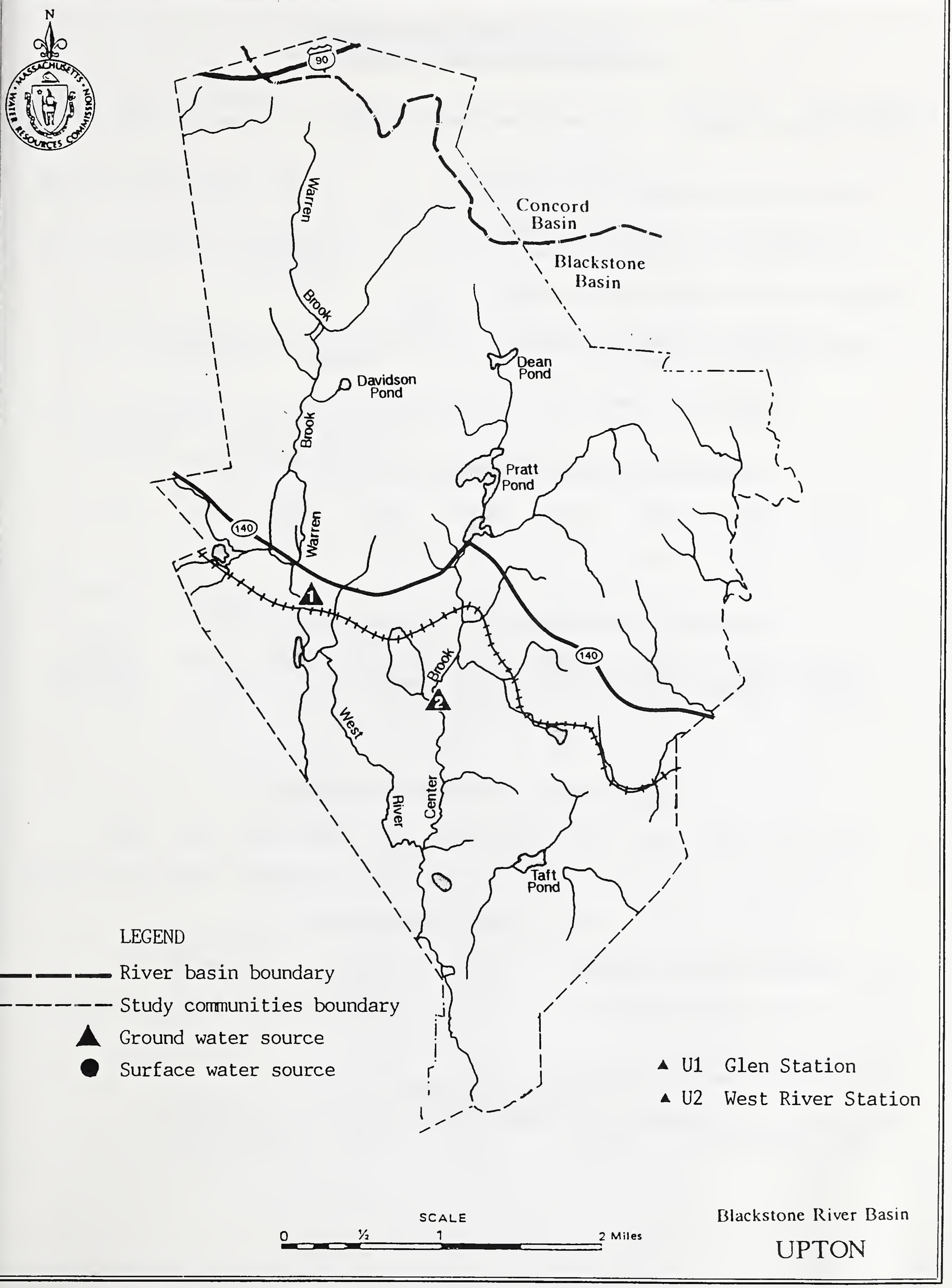
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Wilkinsonville:					
Hatchery Road Well	Blackstone	0.20	0.08	Sub 1	
Manchaug:					
Manchaug Well #1	Blackstone			Sua 1	
Well #2	Blackstone	0.13	0.03	Sua 2	
Well #3	Blackstone			Sua 3	

Total ADD: 0.11 mgd

Total 1988 ADD
on River Basin(s):

Blackstone	0.11 mgd



Blackstone River Basin

UPTON

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Upton
Water Supply Agency: Upton Water Department

River Basin Acreage Distribution			Total Acreage
Blackstone:	13,402	(96 %)	13,975 acres
Concord:	573	(4 %)	(21.85 sq. mi.)

CURRENT PUBLIC WATER SUPPLY USE

Population On Public Supply		Population With On-Site Wells	
Number	Percent	Number	Percent
2349	55	1921	45

Average Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
0.23	NA	NA	NA	0.26	0.28	0.34	0.27	0.27

Maximum Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
0.38	NA	NA	NA	1.11	1.15	0.51	0.41	0.50

1988 Monthly Average Day Demand

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
.33	.26	.24	.24	.28	.33	.30	.25	.25	.28	.21	.21

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):	Blackstone
Volume Discharged by On-Site Septic Systems:	0.22
Volume Discharged by Municipal Sewer System:	0.05

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Upton
Water Supply Agency: Upton Water Department

POPULATION

1970 (U.S. Census)	1980 (U.S. Census)	1986 Census Estimate (1)	1995 (Projected) (2)	2000 (Projected) (3)	2010 (Projected) (3)	2020 (Projected) (3)
3,484	3,886	4,270	4,484	4,692	4,799	5,024

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
4,270	21.84	196

PROJECTED WATER DEMAND

Average Day Demand (mgd)

1986-88 Base ADD	1995	2000	2010	2020
0.29	0.31	0.37	0.42	0.50

Maximum Day Demand (mgd)

1986-88 Base MDD	1995	2000	2010	2020
0.47	0.51	0.59	0.69	0.81

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Upton
Water Supply Agency: Upton Water Department

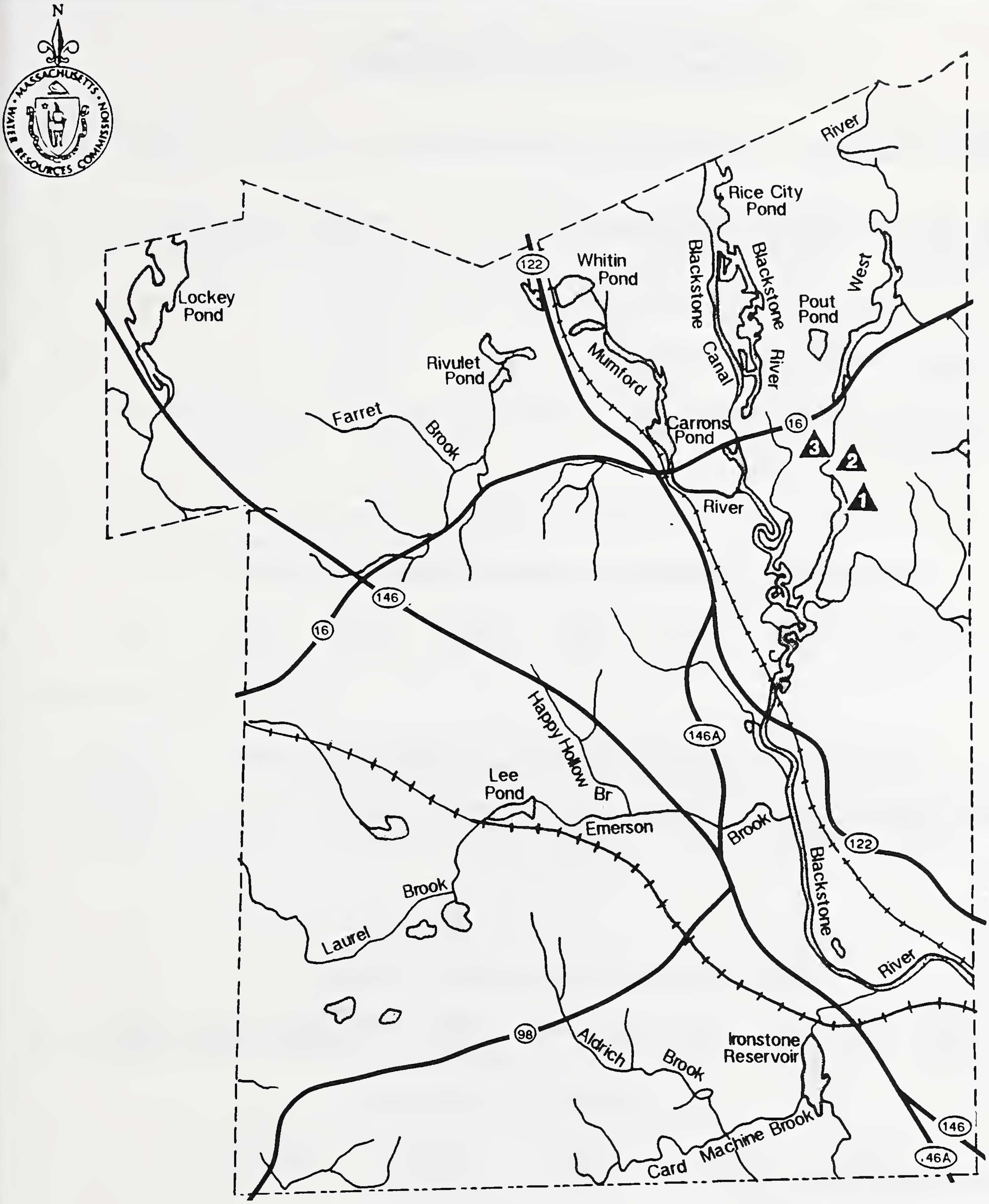
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Glen Ave. Wells	Blackstone	0.40	0.12	U-1	
West River Well	Blackstone	0.80	0.15	U-2	

Total ADD: 0.27 mgd

Total 1988 ADD on River Basin(s):

Blackstone	0.27 mgd



LEGEND

▬ ▬ ▬ River basin boundary

- - - - - - Study communities boundary

▲ Ground water source

● Surface water source

▲ Ux1 Blackstone St. Well #1

▲ Ux2 Blackstone St. Well #2

▲ Ux3 Blackstone St. Well #3

SCALE
0 ½ 1 2 Miles

Blackstone River Basin

UXBRIDGE

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community:Uxbridge
Water Supply Agency: Uxbridge Water Department

River Basin Acreage Distribution		Total Acreage
Blackstone:	19214 (100%)	19214 acres(30.02 sq. mls)

CURRENT PUBLIC WATER SUPPLY USE

Population On Public Supply		Population With On-Site Wells	
Number	Percent	Number	Percent
7582	78	2138	22

Average Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
0.67	0.71	0.70	0.69	0.54	0.59	0.69	0.67	0.75

Maximum Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
0.97	0.90	0.92	0.93	0.72	0.93	0.93	1.11	1.39

1988 Monthly Average Day Demand

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0.65	0.63	0.64	0.68	0.76	0.86	0.77	0.85	0.82	0.81	0.75	0.76

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):	Blackstone
Volume Discharged by On-Site Septic Systems:	0.45
Volume Discharged by Municipal Sewer System:	0.30

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community:Uxbridge
Water Supply Agency: Uxbridge Water Department

POPULATION

1970	1980	1989	1995	2000	2010	2020
(U.S. Census)		Town Census	(Projected)			
		(1)	(2)	(3)	(3)	(3)
8253	8374	9720	10556	11275	11557	12170

(1) Prepared by the town of Uxbridge
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
8950	30.02	298

PROJECTED WATER DEMAND

Average Day Demand (mgd)

1989 Base ADD	1995	2000	2010	2020
0.76	0.98	1.13	1.25	1.37

Maximum Day Demand (mgd)

1986-88 Base MDD	1995	2000	2010	2020
1.14	1.58	1.83	2.02	2.23

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community:Uxbridge
Water Supply Agencies: Uxbridge Water Department

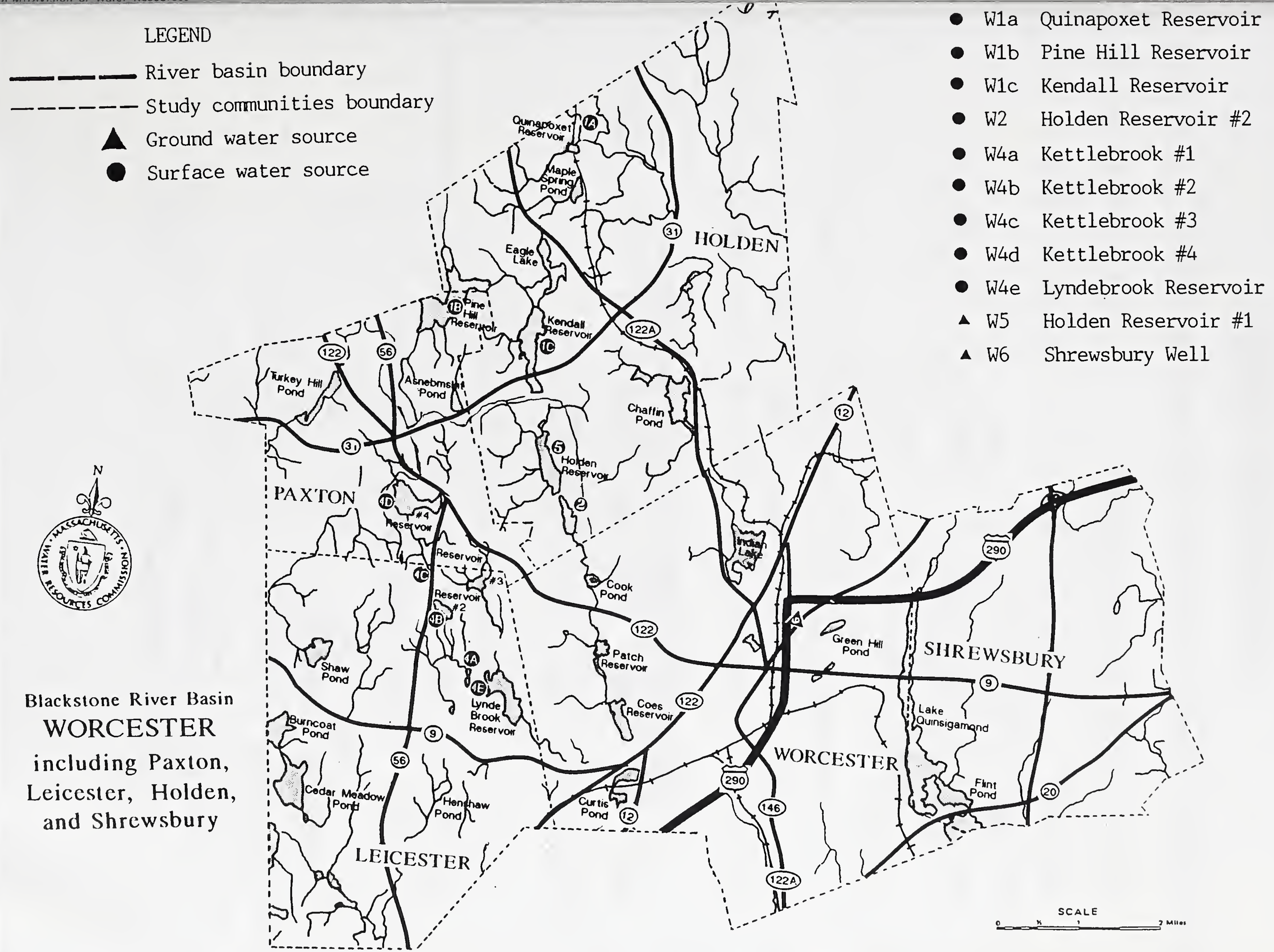
SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Blackstone St. Well #1	Blackstone		0.40	Ux 1	
Well #2	Blackstone		0.34	Ux 2	
Well #3	Blackstone		0.003	Ux 3	
		1.00			

Total ADD: 0.75 mgd

Total 1988 ADD on River Basin(s):

Blackstone	0.75 mgd



Blackstone River Basin
WORCESTER
including Paxton,
Leicester, Holden,
and Shrewsbury

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Worcester
Water Supply Agency: Worcester DPW, Water Operations

River Basin Acreage Distribution			Total Acreage
Blackstone:	24,487	(99 %)	24,659 acres
Nashua:	172	(1%)	(38.53 sq. mi.)

CURRENT PUBLIC WATER SUPPLY USE

Population On Public Supply		Population With On-Site Wells	
Number	Percent	Number	Percent
157,724 (Worcester only)	99.9	46	<1

*Average Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
25.67	24.84	21.34	22.82	25.32	25.50	26.39	26.17	26.78

*Maximum Day Demand (million gallons per day)

1980	1981	1982	1983	1984	1985	1986	1987	1988
34.44	32.78	32.53	35.05	34.15	34.97	36.63	37.61	39.92

* Worcester only - does not include water sold

1988 Monthly Average Day Demand

Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
26.4	26.5	25.6	25.1	25.4	30.1	30.4	33.2	28.4	26.6	25.0	19.0

1988 WASTEWATER DISCHARGE:

Receiving River Basin(s):	Blackstone
Volume Discharged (mgd) by On-Site Septic Systems:	1.34
Volume Discharged by Municipal Sewer System:	25.44

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Worcester
Water Supply Agency: Worcester DPW, Water Operations

POPULATION

1970	1980	1986	1995	2000	2010	2020
(U.S. Census)		Census Estimate	(Projected)			
		(1)	(2)	(2)	(2)	(2)
176,572	161,799	157,770	167,192	167,383	168,395	177,133

(1) 1986 Census Estimate prepared by U.S. Bureau of Census
(2) Prepared by the Massachusetts Institute for Social and Economic Research (MISER)
(3) OWR's extension of MISER 1995 Projections

POPULATION DENSITY

1986 Census Estimate	Area of Community (in square miles)	1986 Population Density (persons per square mile)
157,770	38.53	4095

PROJECTED WATER DEMAND

Average Day Demand (mgd)

1986-88 Base ADD	1995	2000	2010	2020
26.45*	30.06	31.33	32.92	36.02

* also sold 0.37 to other water supply systems

Maximum Day Demand (mgd)

1986-88 Base MDD	1995	2000	2010	2020
38.05	44.06	45.12	47.41	51.87

OFFICE OF WATER RESOURCES
WATER SUPPLY FACTS - SUMMARY

Community: Worcester
Water Supply Agency: Worcester DPW, Water Operations

SOURCES OF PUBLIC WATER SUPPLY

Name of Source	Basin Location	Pumping Capacity	1988 ADD of Source (MGD)	DWR Map Symbol	Notes
Quinapoxet Res.	Nashua			W-1a	
Pine Hill Res.	Nashua			W-1b	Gravity to Kendall
Kendall Res.	Nashua		12.97	W-1c	Gravity to Holden #1
Holden Reservoir #2	Blackstone			W-2	
Holden Reservoir #1	Blackstone		10.71	W-5	
Kettlebrook #1	Blackstone			W-4a	Gravity to Lyndebrook
Kettlebrook #2				W-4b	
Kettlebrook #3				W-4c	
Kettlebrook #4				W-4d	
Lyndebrook Res	Blackstone		3.50	W-4e	
Shrewsbury Well	Blackstone	0.79		W-6	off line
Water Sold			(0.40)		

Total ADD: 26.78 mgd

Total 1988 ADD on River Basin(s):		
Blackstone	13.81	
Nashua	12.97	mgd